Estimation of Abundance and Mortality of Emigrating Chum Salmon and Chinook Salmon in the Chena River, Alaska

By

Brent David Peterson

RECOMMENDED:

Advisory Committee Chair

Director of Fisheries Division

APPROVED:

Dean, School of Fisheries and Ocean Sciences

Dean of the Graduate School

Date 2-17-97

ESTIMATION OF ABUNDANCE AND MORTALITY OF EMIGRATING CHUM SALMON AND CHINOOK SALMON IN THE CHENA RIVER, ALASKA

A

THESIS

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

By

Brent David Peterson, B.S.

Fairbanks, Alaska

May 1997

Abstract

During May-June, 1995 and 1996, the outmigration of juvenile chum salmon (*Oncorhynchus keta*) and chinook salmon (*O. tschawytscha*) was sampled with floating traps in the area of the Chena River Lakes Flood Control Project, Chena River, Alaska. Catch-per-unit-effort (CPUE) was higher at night than day for chinook juveniles, but not for chum juveniles. CPUE of both species decreased as the season progressed, but usually increased during higher-discharge events. CPUE is standardized by time; discharge was monitored as a covariate but was not included in CPUE calculations. The Jolly-Seber family of models was used on recapture data of fin-clipped fish to obtain estimates of abundance and survival in 1996. Abundance estimates were 266,104 chum salmon (95% CI 128,031 - 404,177) and 171,952 chinook salmon (95% CI 146,342 - 197,561) during the May-June outmigration period. These abundance estimates are probably underestimates of the entire Chena River population. Survival estimates were 0.135 (95% CI 0.042 - 0.228) for chum salmon and 0.713 (95% CI 0.492 - 0.935) for chinook salmon over the same period.

Table of Contents

List of Figures

List of Tables

Acknowledgments

This study was funded by the United States Army Corps of Engineers (Corps) and administered through the Alaska Cooperative Fish and Wildlife Research Unit (AKCFWRU). I thank Jim Reynolds for his advice and guidance through the course of this project and my advisory committee members, Mark W. Oswood and Dana L. Thomas, for their insight in the development of the project and their review of this thesis. Invaluable in-kind support, consistently beyond the call of duty, was provided to the project by Corps personnel at the Chena River Lakes Project Office. I thank Gary Todd and the Soldotna branch of the Alaska Department of Fish and Game for the use of their inclined plane trap in 1996. I thank Norma Mosso, Kathy Pearse, and Judy Romans, AKCFWRU administrators, for their motherly advice in helping me stay out of trouble and keeping my paperwork in order. I thank Joy Heimgartner for her hard work in managing all our field equipment. I thank Michael Daigneault, Ted Lambert, and Kevin VanHatten, fellow graduate students, and our field technicians, Andrew McCarthy, Stephen Bethune, Jeff Estensen, Ira Edwards, and Steven Stroka, for their help in data collection and analysis. I also thank Jay Taylor for his assistance and expertise with computers. Finally, a big thank you to all my friends who have provided moral support and encouragement throughout my graduate studies.

Introduction

The Chena River Lakes Flood Control Project was authorized in 1968 and completed in 1973. It was designed to protect Fairbanks, Alaska, from flooding by the Chena River. The main features of the project are a 11.3-km diversion dam across the Chena River in the vicinity of North Pole, Alaska (Figure 1), and a 33.3-km system of levees and groins along the nearby Tanana River. The diversion dam includes flood control gates on the Chena River and a cleared floodway that contains a temporary reservoir of floodwater when the gates are partially closed to control downstream discharge (i.e., a control event). The maximum flow objective for the project is 12,000 cfs through downtown Fairbanks.

Thus far, the three largest control events were in 1985, 1991, and 1992, all during the spring breakup period (May to early June) when juvenile chum salmon (*Oncorhynchus keta*) and juvenile chinook salmon (*O. tschawytscha*) begin downstream migration to the Bering Sea via the Yukon River drainage. Chum salmon outmigrate soon after hatching, at age-0, during peak flow associated with spring breakup. Chinook salmon outmigrate as age-1 or age-2 juveniles over a longer period, but primarily May and June (Williamson 1984).

Public concern has been expressed that control events during spring may affect these outmigrants through delay and, ultimately, increased mortality due to entrapment in the floodway or physical damage due to the dam hydraulics. During 1981-1983, the United States Fish and Wildlife Service documented the timing and duration of outmigration just downstream of the floodgates, but this study was not designed to evaluate the effects of project operation on outmigration or abundance (Williamson 1984).

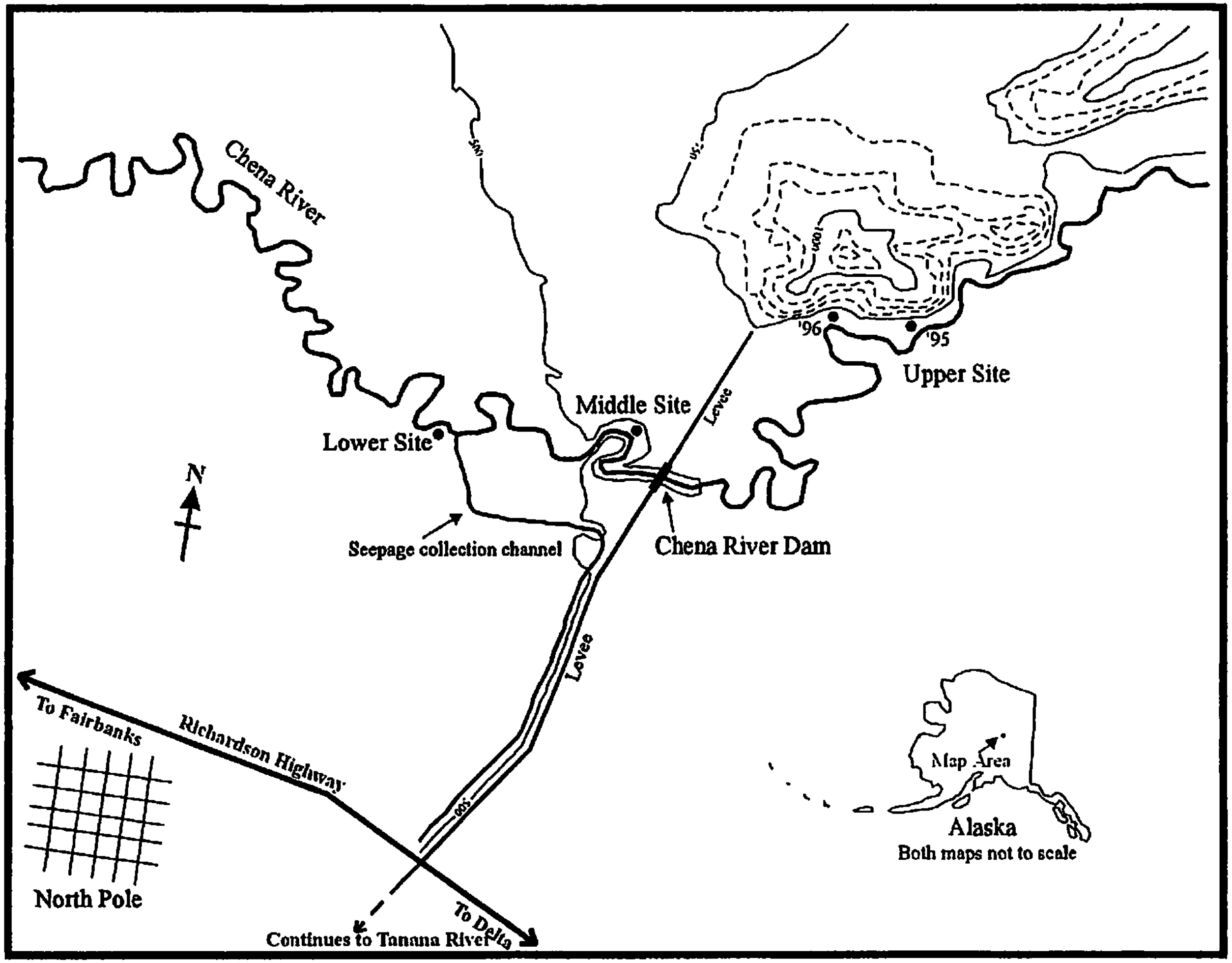


Figure 1. The location of the Chena River Dam in reference to Alaska and North Pole, Alaska. The Chena River flows from east to west. Capture sites are marked; the location of the upper site was moved downstream in 1996 to improve capture rates.

The purpose of my research was to evaluate the effects, if any, of the operation of the Chena River Lakes Flood Control Project (hereafter called the Chena River Dam) on the outmigration and abundance of juvenile chum and chinook salmon in the Chena River. My project involved a mark-recapture experiment designed to compare the movement, abundance, and survival of outmigrants in event years with that in non-event years. The objectives for my study were to:

1. implement capture techniques to successfully catch outmigrating juvenile chum and chinook salmon;
2. implement marking techniques to successfully mark juvenile salmon, without injury, for recapture; and
3. employ mark-recapture methodology to provide estimates of abundance and survival of outmigrating chum salmon and chinook salmon in the Chena River.

Study Area

During summer 1994, feasibility studies were conducted to evaluate potential study sites upstream and downstream of the Chena River Dam for the 1995 field season. For efficiency, one primary sampling site was selected in each area. Downstream, a site was selected at the end of the south seepage collection channel because this point on the Chena River is accessible by both road and boat. There is also a possibility of outmigrants traveling through the seepage collection channel during flood events. In addition, the lower site was far enough downstream to avoid the turbulence of dam discharge during control events (Figure 1). Upstream, a site was selected next to a bluff at the end of an access trail from the north foot of the dam (Figure 1). This site was far enough upstream to minimize exposure to the backwaters from the floodway during a control event, and was accessible by boat, ATV, or foot. The bluff at the upstream site provided a dependable deepwater area for trapping and higher ground for a secure camp.

During the 1995 field season both sites were used as planned. However, upon completion of this first field season two problems with our selected study sites became apparent. First, the upper site did not provide adequate flows throughout the sampling period. As the revolution rate of the rotary screw trap (an index of current velocity, and therefore discharge) dropped, catch rates fell to an unacceptable level (Figures 2 and 3); there were too few marked fish being released at the upper site for recaptures at the lower site to be probable. Therefore, the upper site trap was moved approximately one mile downstream to an area with more constricted and sustained flow for the 1996 field season (Figure 1). The new location for this site maintained the favorable aspects of the previous location (i.e.,

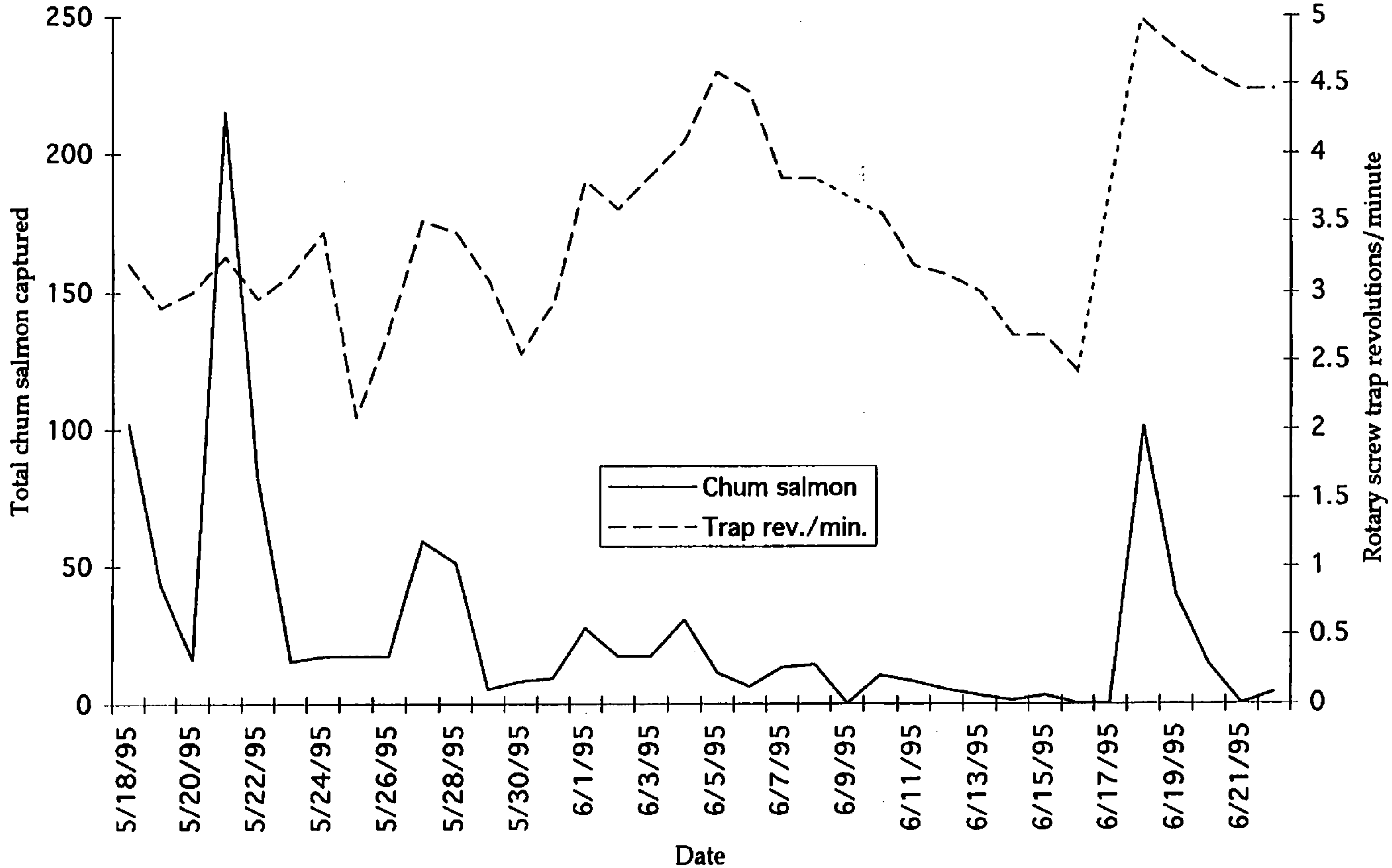


Figure 2. Total numbers of chum salmon fry captured per day and current velocity at the upper site, 1995.

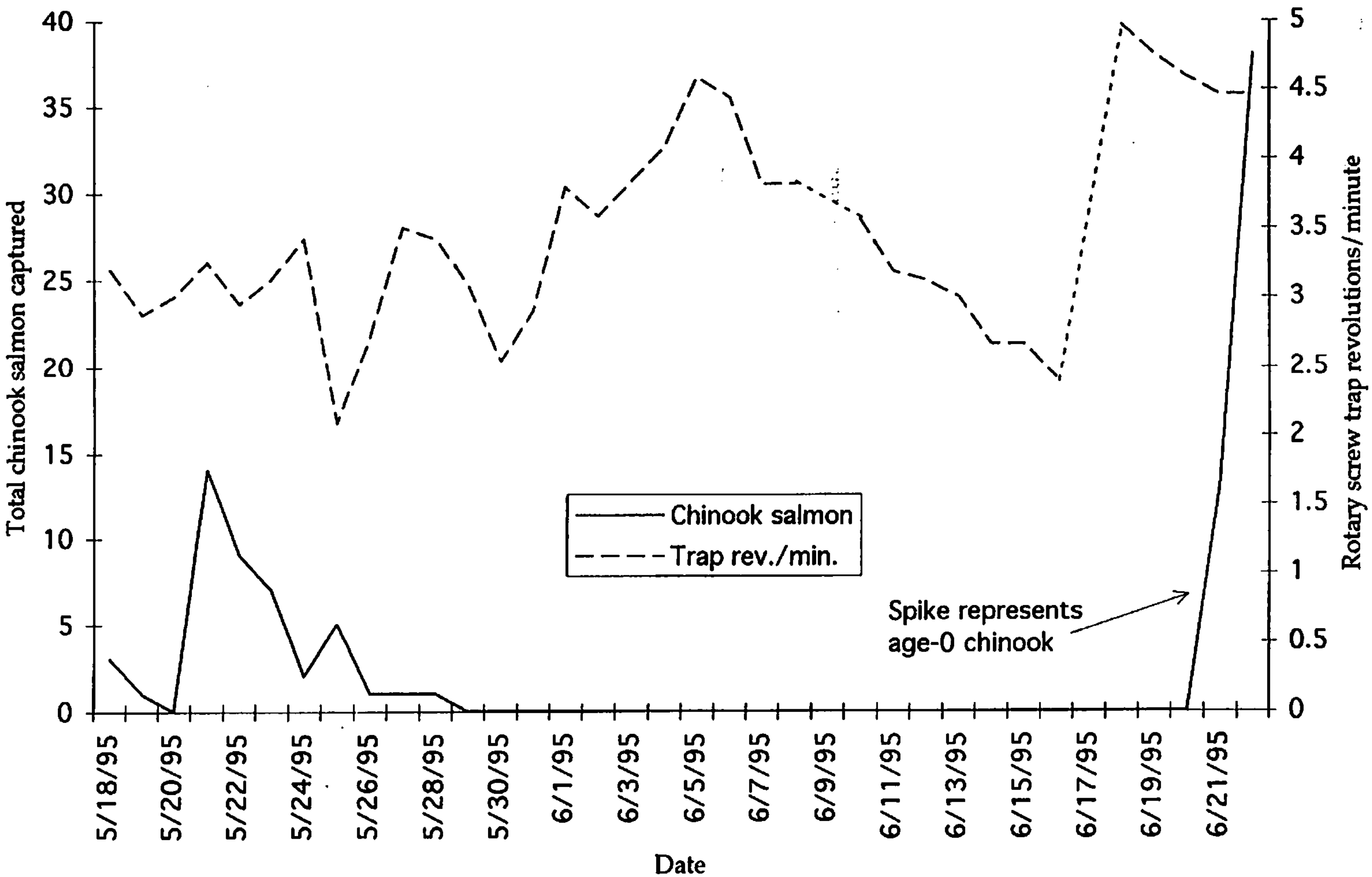


Figure 3. Total numbers of chinook salmon smolts captured per day and current velocity at the upper site, 1995.

minimal exposure to flooded backwaters and trail access) while promising higher catch rates in 1996.

The second problem concerned the failure of minnow traps as a viable means of catching juvenile chum and chinook salmon (see below). In order to estimate survival for an open population, three capture sites are needed. Therefore, a third trap was necessary for the 1996 season if we were to meet our objectives. The middle site was located on the north side of the river, two bends downstream from the dam (Figure 1). The particular location for this trap was chosen because it is road accessible and protected from any turbulent waters downstream from the Chena River Dam during a flood event.

All sites were located far enough apart to avoid violating the assumption of complete mixing with unmarked fish (Table 1). Raymond (1979) indicated that equal mixing of released fish with unmarked fish took place within a short distance upriver in his trap efficiency studies. Two river bends were considered a minimum to ensure complete mixing in my study.

Table 1. River kilometers (miles) between major landmarks in the Chena River study.

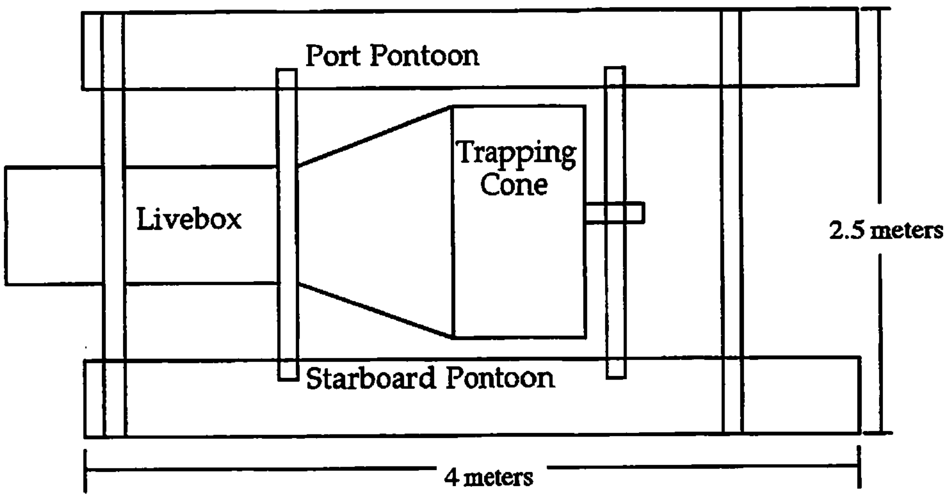
	Upper Site	Chena River Dam	Middle Site	Lower Site
Upper Site	-	10.2 (6.3)	11.8 (7.3)	15.8 (9.8)
Chena River Dam	10.2 (6.3)	-	1.6 (1.0)	5.6 (3.5)
Middle Site	11.8 (7.3)	1.6 (1.0)	-	4.0 (2.5)
Lower Site	15.8 (9.8)	5.6 (3.5)	4.0 (2.5)	-

Methods

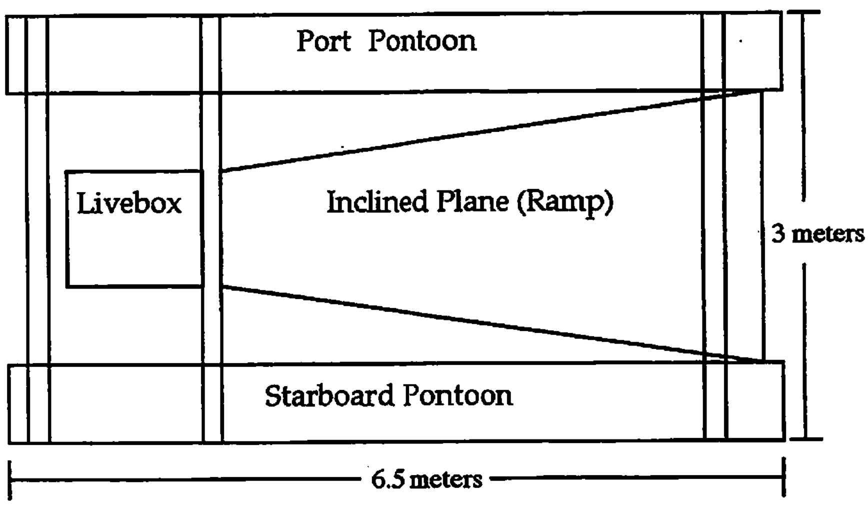
Fish Capture

A feasibility study began during the late summer of 1994 and was completed prior to sampling in May, 1995. Rotary screw traps have been used in glacial (Thedinga et al. 1994) and coastal rivers (Bendock, Alaska Department of Fish and Game, Soldotna, personal communication) with success, but they have not been used extensively on meandering interior rivers such as the Chena. Results of this study indicated that 1.524 meter (5-foot) diameter rotary screw traps (Figure 4a) would operate in current velocities and water depths typical of the Chena River. The screw traps, manufactured by E.G. Solutions of Portland, Oregon, are quite large and heavy (≈2,200 kilograms), so they were lowered into the water by U.S. Army Corps of Engineer personnel fully assembled using a front-end loader. One screw trap was located at the upper site and one at the lower site in 1995. Trapping was to begin as early as possible following breakup in May based on Williamson's (1984) findings that the period of peak outmigration occurs between May 5th and May 16th for Chena River salmon stocks.

The calibration work carried out during the feasibility study and the 1995 field season allowed us to establish a linear relationship between trap revolution rate and current velocity (Figure 5) with an F value of 1,498 (highly significant, p-value < 0.001); all regression assumptions were met (Neter et al. 1990) and there were no statistical outliers. This enabled us to forego taking velocity measurements in the 1996 field season. A third order polynomial curve was also considered for this plot (Figure 6), but the improvement in curve fit did not justify the increase in



a. Rotary screw trap.



b. Inclined plane trap.

Figure 4. Rotary screw trap and inclined plane trap used on the Chena River.

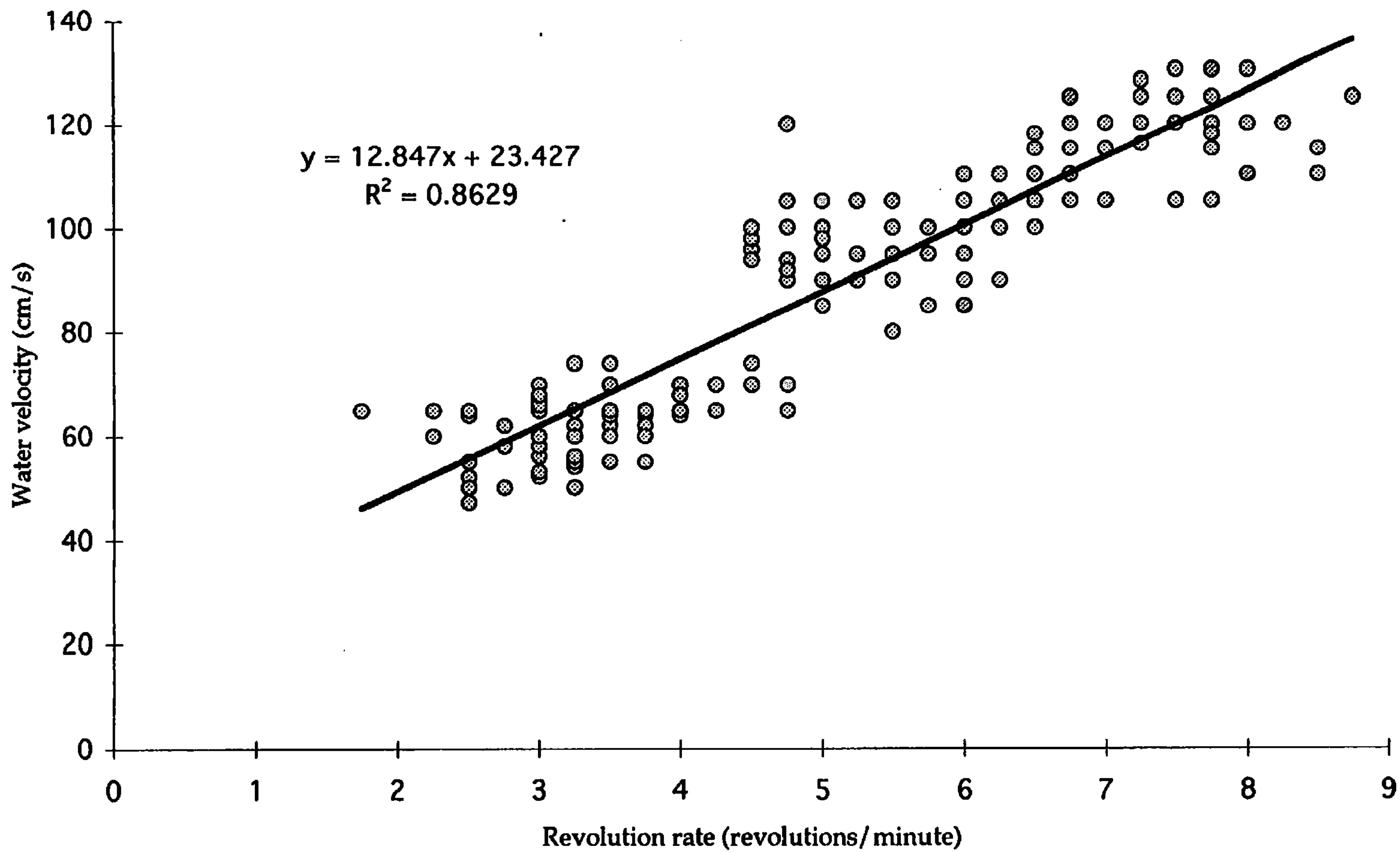


Figure 5. The linear relationship between water velocity and trap revolution rate as measured at the upper and lower sites in 1995.

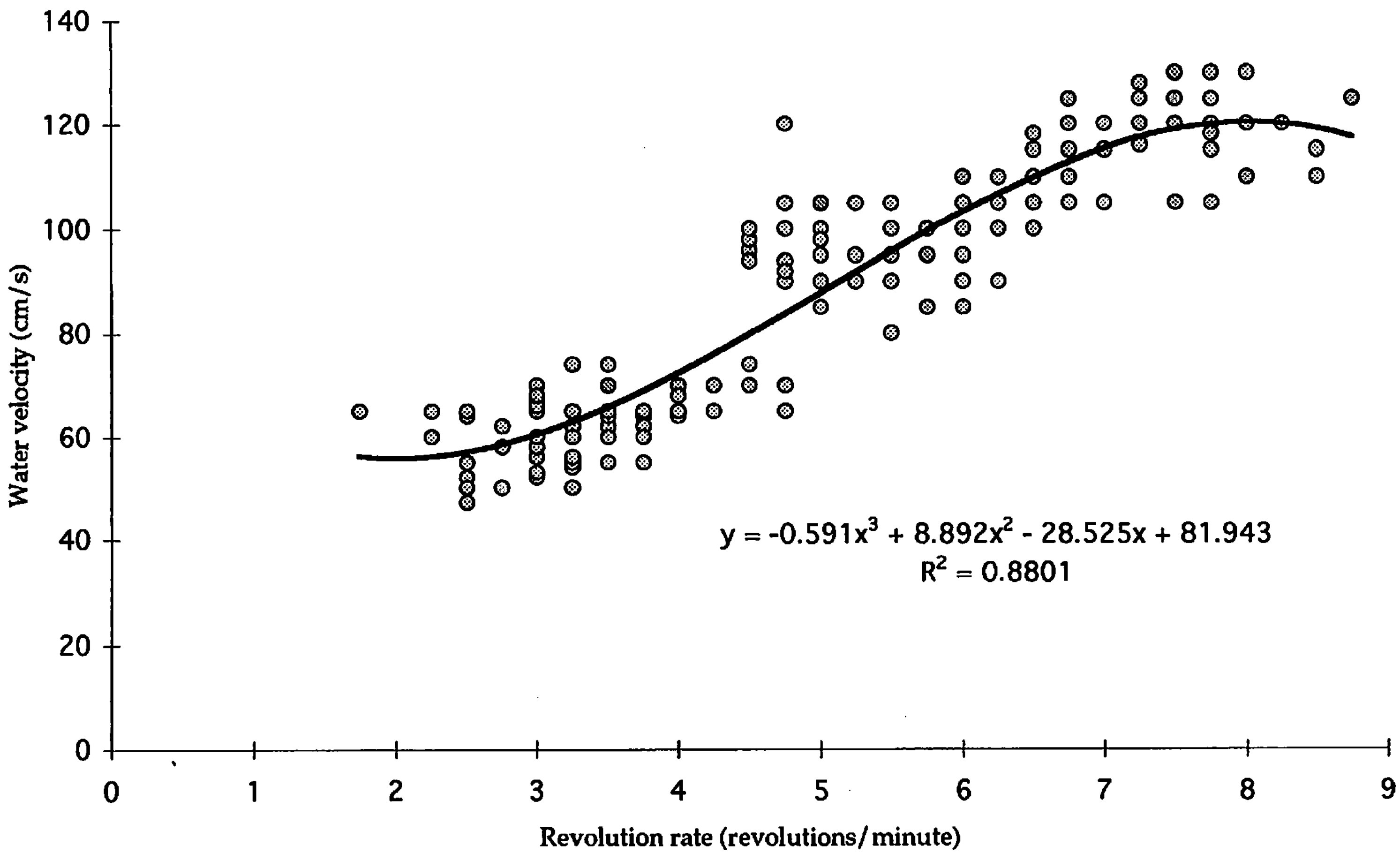


Figure 6. The polynomial relationship between water velocity and trap revolution rate as measured at the upper and lower sites in 1995.

complexity of the relationship (i.e., the adjusted R^2 value went up, but not by a statistically significant amount).

Minnow traps, baited with cured salmon roe, were intended for use at a third capture site during the 1995 field season to increase capture efficiency for chinook smolts (Healey 1991) and chum fry (Faurot 1989). Following one week of extremely low catches in these traps (average < 1 salmon/night/trap), their use was abandoned. In 1996 a modified inclined plane trap (Figure 4b) was added and was located at the middle site (Figure 1). We borrowed the trap under cooperative agreement from the Alaska Department of Fish and Game in Soldotna, built by them to their specifications (Todd 1990). In 1995, two alternate capture methods were implemented at the upper site to increase the numbers of marked fish released. A hand dipnet was used along cut banks and a seine was used in backwater areas; neither was used in 1996.

Following the feasibility study it was determined that an efficient and standardized method had to be implemented to remove captured fish from the live box of the rotary screw traps. Without such a standardized technique the effort taken by the crew to extract the fish would have been dependent upon the current weather (i.e. less effort with worse weather). The main problem was the size of the live box. With dimensions of 1.5 meters long by 0.9 meters wide by 0.6 meters deep the fish were very difficult to remove; seeing and catching fish was difficult. To solve this problem, we designed a wooden "sweeper" which could be used to concentrate the fish in the back of the trap for easy dipnetting. The metal sweeper consisted of a sheet of perforated, galvanized steel framed by aluminum. After sweeping, the fish were concentrated in a 0.15 meter long by 0.9 meter wide by 0.6 meter deep cube at the downstream end of the livebox. A long-handled dipnet was modified to fit this new area. Most of the fish could be removed from the livebox in one pass of the net; several passes were always made to capture the more elusive fish. This dipping problem did not occur with the inclined plane trap because the livebox could be raised as high as necessary to concentrate the fish in a small area.

All traps were positioned on the outside bend of the river, for it has been noted in the literature (Scully and Buettner 1986) that smolts tend to follow the thalweg while outmigrating, so the greatest number of fish should be concentrated in the swifter current.

Based on feasibility study results and criteria mentioned in the results, a length of 1 hour was considered an optimal period of time to fish the traps before emptying the livebox. This 1 hour period was used throughout the 1995 field season and for most of the 1996 field season. However, a monitoring protocol had to be established which would allow long-term, low-intensity monitoring of the Chena River salmon outmigration following the completion of our project. In order to reach this objective we needed to determine if the rotary screw traps lost efficiency when allowed to run for more than 1 hour at a time. Near the middle of the 1996 field season, a small experiment was implemented at the lower site to determine if 3 hour periods were as efficient as 1 hour periods (i.e., 3 hours of fishing effort would catch three times as many fish as 1 hour of effort).

Fish Marking

Marking outmigrating smolts was a complex task due to the small size of the fish, the large number of fish marked, and the effect and effectiveness of the mark itself (Fry 1961 and Arnold 1965). For these reasons, we attempted to use a tagging procedure that required as little individual handling as possible while still effectively marking the fish. Several methods were proposed for marking juvenile chum and chinook salmon for recapture on the Chena River. These methods included coded-wire tags, fluorescent dye, Bismarck Brown Y dye, and fin clips. During the 1994 feasibility study and the 1995 field season all methods except fin clips were rejected.

Use of coded-wire tags is a well-established technique for marking juvenile salmonids. However, until recently, a large, complicated equipment configuration was required to perform this work. Hand-operated equipment, suitable for marking hundreds to thousands (as opposed to millions) of fish at remote camps such as the sites required for the Chena River project, was available for our research. The portable coded-wire taggers (CWT), made by Northwest Marine Technology of Shaw Island, Washington, are composed of two general parts: a tagging unit which inserts the tag into the fishes' nose cartilage and a detection wand to determine if the tag has been placed in the fish. The tagger inserts a metal wire tag which is magnetized for detection purposes. A tagger was rented in 1994 to determine it's utility for the 1995 field season. Several dozen age-0 chinook were tagged in late August. We found that coded-wire tagging equipment would be effective in marking chinook smolts (>50 mm), but not chum fry due to their small size (≈30 mm) respective to the size of the smallest tag (1.1 mm). The CWT was rejected as a marking method for this reason.

Fluorescent dye was used successfully by Pauley and Troutt (1988), but the chum fry once again presented a unique problem. Scale formation is required for retention of fluorescent dye granules if immersion or painting are used (Pauley and Troutt 1988), but chum fry do not form scales until they reach a mean length of at least 41.5 to 42.4 mm in length (Bilton 1988). Therefore, fluorescent dye was also rejected as a marking method.

Bismarck Brown Y dye showed promise for mass-marking juvenile outmigrants due to it's lack of toxicity to salmonids (Fraley and Clancey 1988) and it's retention time (Ewing et al. 1990). However, it was determined during the 1995 field season that chum fry were holding along the banks of the river much longer than expected. The dye faded during this holding period, making mark recognition difficult and partially accounting for the extremely low number of recaptures in 1995 (see Appendix 4). Additionally, Bismarck Brown Y stains the fish close to the natural coloration of non-smolted fry so as to make the mark difficult to detect in the poor lighting experienced during nighttime hours. The use of Bismarck Brown Y was abandoned during the 1995 field season in favor of fin clips.

Fin clips were an obvious solution to the problems we had encountered with other marking methods. A partial caudal fin clip does not permanently disfigure the fish (O'Grady 1984) and introduces little additional mortality (Mears and Hatch 1976); regeneration of clipped caudal fins is a known phenomenon, but the clip remains detectable beyond the scope of our two month study (Johnsen and Ugedal 1988). Also, fin clips are easily recognizable and difficult to overlook. Fin clips have the apparent disadvantage of requiring individual attention for each fish marked. However, our sub-project on injury and descaling required the same level of attention. An upper caudal fin clip was given to fish captured at the upper site, a lower caudal fin clip to fish captured at the middle site, and fish were observed for marks at the lower site. The same marking scheme was used for chum and chinook outmigrants to minimize complexity of the procedure.

To facilitate marking and examination, all captured outmigrants were anesthetized using a 100 mg/L solution of tricaine methanesulfonate (MS-222) as described for juvenile chinook by Sims and Miller (1982). The fish succumbed to the anesthetic within 1 minute and fully recovered within 0.5 hour after placement in fresh water.

Mark-Recapture Methodology

The mark-recapture work was laid out as a classical mark-recapture experiment with the main goal of determining the effects, if any, of the Chena River Dam on abundance and survival of outmigrating chum and chinook salmon smolts. The target population for this study was the chum and chinook outmigrants that were exposed to the dam. Initially, it was assumed that all fish were spawning above the dam, but circumstantial evidence from Alaska Department of Fish and Game electrofishing studies on the Chena River in 1996 showed chum spawning below the dam in several areas. Chinook were apparently spawning below the dam as well, but their numbers were extremely low (Wuttig, Alaska Cooperative Fish and Wildlife Research Unit, personal communication).

Outmigrating salmon in the Chena River represent an open population (immigration, emigration, births, and deaths possible). Therefore, the Jolly-Seber family of models were examined for their applicability to the population. These models make the following assumptions (Pollock et al. 1990):

1. Every animal present in the population at the time of the i^{th} sample has the same probability of capture,

2. Every marked animal present in the population immediately after the i^{th} sample has the same probability of survival until the next sampling time,

3. Marks on recaptured fish are not lost or overlooked, and

4. All samples are instantaneous and each release is made immediately after the sample.

Our study meets all of these assumptions. Since similar capture techniques are used at each trapping site, each salmon has the same probability of capture (assuming consistency of behavior, such as following the thalweg). All marked fish have the same probability of survival because they are all handled in the same manner and receive similar marks. Caudal fin clips are very difficult to overlook due to their relatively large size and slow regrowth rate (Johnsen and Ugedal 1988). Finally, all samples taken occurred over a short time period and releases of fish were made immediately upon recovery from the anesthetic.

In order to estimate survival for a population there must be at least three sampling events. Events in our study were represented by the three trap sites. Two of the three capture sites had rotary screw traps and the third site had an inclined plane trap. A third screw trap was not purchased for the 1996 field season due to the prohibitive cost of the traps (~$10,000 per trap). The use of two trap types will reduce any "trap happy" or "trap shy" responses (Pollock et al. 1990), helping to lower trap bias.

Specific notation is used in the application of mark-recapture theory by Pollock et al. (1990); the population parameters are:

M_i = the number of marked animals in the population at the time the sample is taken

N_i = the total number of animals in the population at the time the sample is taken

B_i = the total number of new animals entering the population between this interval and the next which are still in the population at the time the next sample taken (cannot be estimated with three sample sites, but this is not a parameter in which we are interested in this study)

ϕ_i = the survival probability for all animals between this interval and the next

p_i = the capture probability for all animals in the particular sample

The sample statistics are:

m_i = the number of marked animals caught in this sample

u_i = the number of unmarked animals captured in this sample

n_i = the total number of animals captured in the sample ($m_i + u_i$)

R_i = the number of n_i released after the sample is taken (sometimes less than n_i if samples taken or losses occur)

r_i = the number of the R_i animals released that are captured again, later

z_i = the number of animals captured before this sample site and captured again later, but not captured at this sample site

Of the above listed statistics, the one that requires three sampling sites is z_i.
Unbiased estimators of the parameters given above (Pollock et al. 1990) are:

$$\tilde{M}_i = m_i + \frac{(R_i + 1)z_i}{r_i + 1}$$

$$\tilde{N}_i = \frac{(n_i + 1)\tilde{M}_i}{m_i + 1}$$

$$\tilde{\phi}_i = \frac{\tilde{M}_{i+1}}{\hat{M}_i - m_i + R_i}$$

$$\tilde{B}_i = \tilde{N}_{i+1} - \tilde{\phi}_i(\tilde{N}_i - n_i + R_i)$$

$$\tilde{p}_i = \frac{m_i}{\tilde{M}_i}$$

Calculations for variances and covariances of the estimators are given in Pollock et al. (1990), but are not shown here. They were calculated, along with the appropriate parameters above, with the computer program JOLLY, as described by Pollock et al. (1990). Several models are available within the Jolly software package; the final selected model used is determined with the model-selection algorithm within the software and a thorough examination of the raw data.

Although abundance estimates are calculated with the computer program JOLLY (Pollock et al. 1990), mortality is estimated using the program RELEASE (Burnham et al. 1987). Two computer programs are used because JOLLY cannot compute an iterative solution for survival probability if all capture histories are not represented, as in this study, due to low capture probability; RELEASE is used to produce these estimates. JOLLY gives the abundance estimates because RELEASE only computes survival estimates. Each program is therefore utilized to estimate the parameter for which it is best suited. For both software programs, the data are entered as a capture history for the respective species. Because there are three possible capture sites, there are $2^3 = 8$ possible capture histories. Appendix 1 provides a description of each possible capture history along with related assumptions and the possible effect on parameter estimates.

Results

Sampling periods were May 16 - June 22, 1995, and May 6 - June 10, 1996, generally during the hours from 8:00 PM to 6:00 AM. Sampling began and ended earlier in 1996 based on our observations from the 1995 field season. Appendix 2 contains information on non-target species captured during both field seasons. Appendix 4 contains a complete set of raw data, including fish captured via all methods, water temperatures, and rotary screw trap revolutions where appropriate.

Physical Factors Affecting Outmigration

All camps were established in early May, during breakup, and remained until outmigration of juvenile salmonids declined to an insignificant level (Figures 7 and 8). Age-0 chinook began appearing in our traps near the first week in June each year, but in 1995 we mistakenly identified them as age-0 chum salmon, designated by "?" in Figure 7. Clear distinctions between age-0 chinook and chum were made in 1996. The cumulative frequency distributions (Figures 9 and 10) also indicate that the majority of the outmigrants had passed the traps due to the flattening of the curve near the end of the sampling period.

Discharge measurements were taken at the Chena River Dam on a daily basis by U.S. Army Corps of Engineer personnel and were assumed to be equal to the discharge at the two lower sites. On average, discharge was substantially higher in 1995 than in 1996 (Figure 11). A minor flood event occurred immediately after the 1995 field season (discharge >8,000 cfs), but nearly all of the outmigrants (all chum fry and age-1 and older chinook smolts) had left the river by this time.

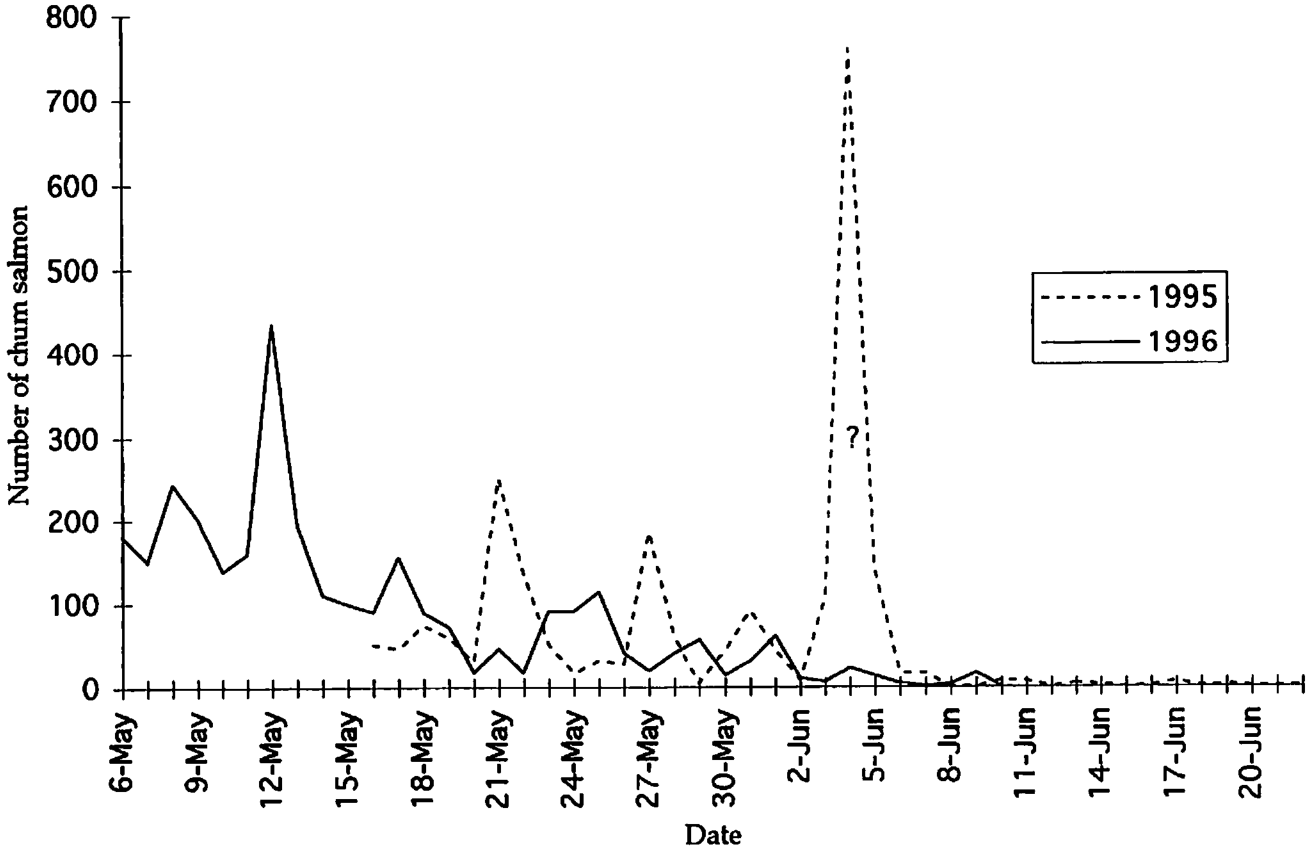


Figure 7. Chum salmon fry captured per day at the lower site, 1995 and 1996. The "?" symbol indicates that there may be a large number of age-0 chinook salmon present in the peak (see text).

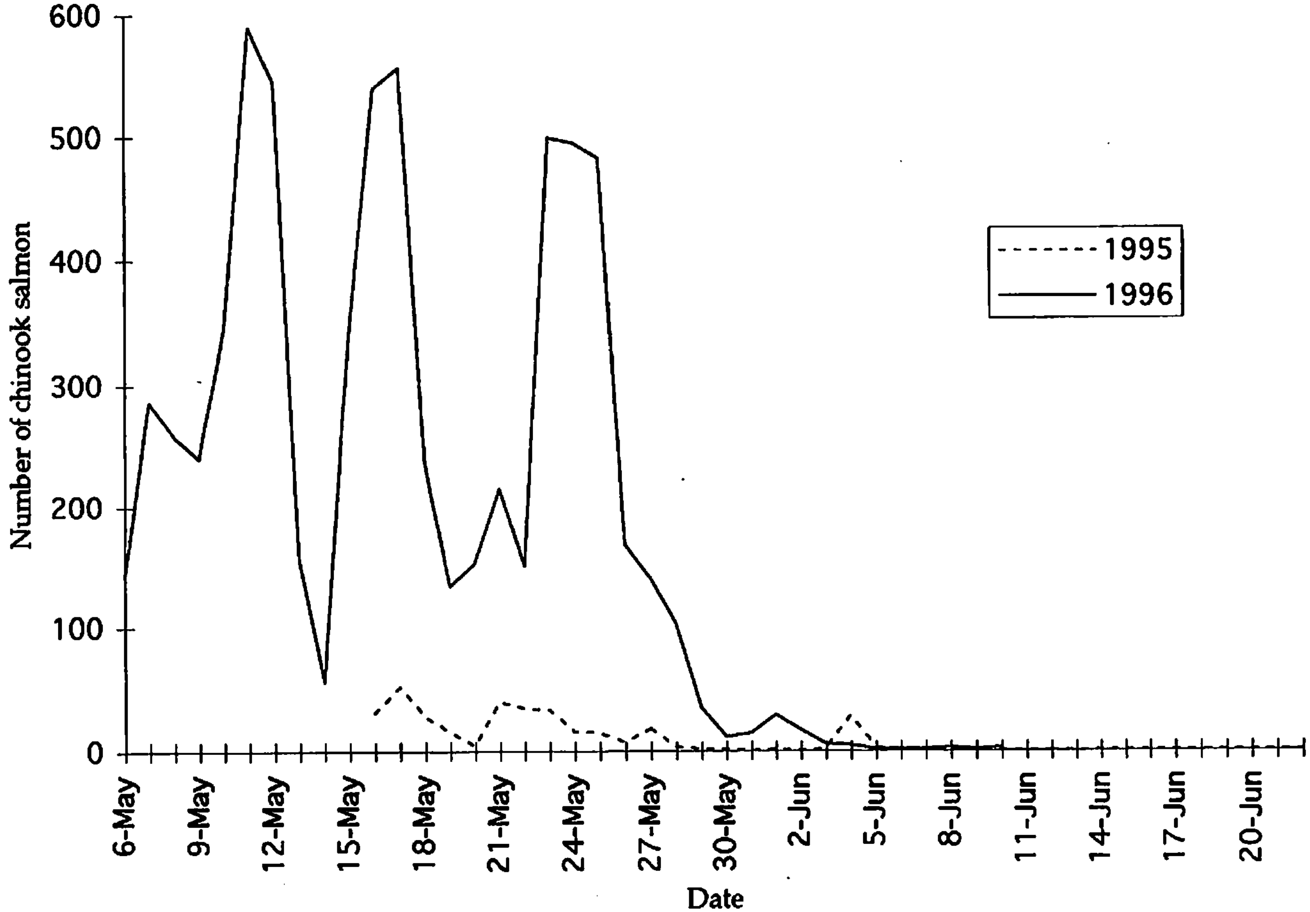


Figure 8. Chinook salmon smolts captured per day at the lower site, 1995 and 1996.

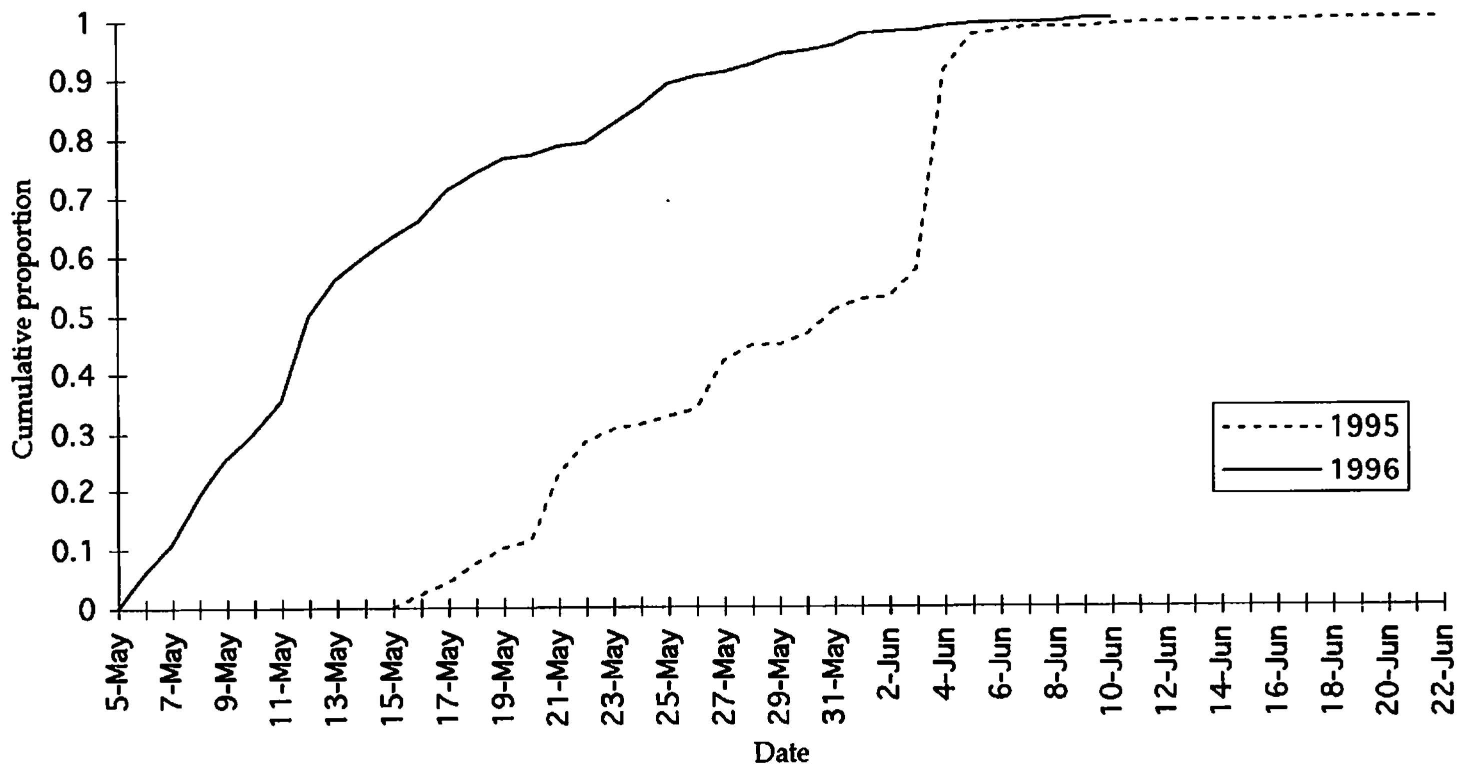


Figure 9. Cumulative proportion distribution for chum salmon fry captured at the lower site, 1995 and 1996.

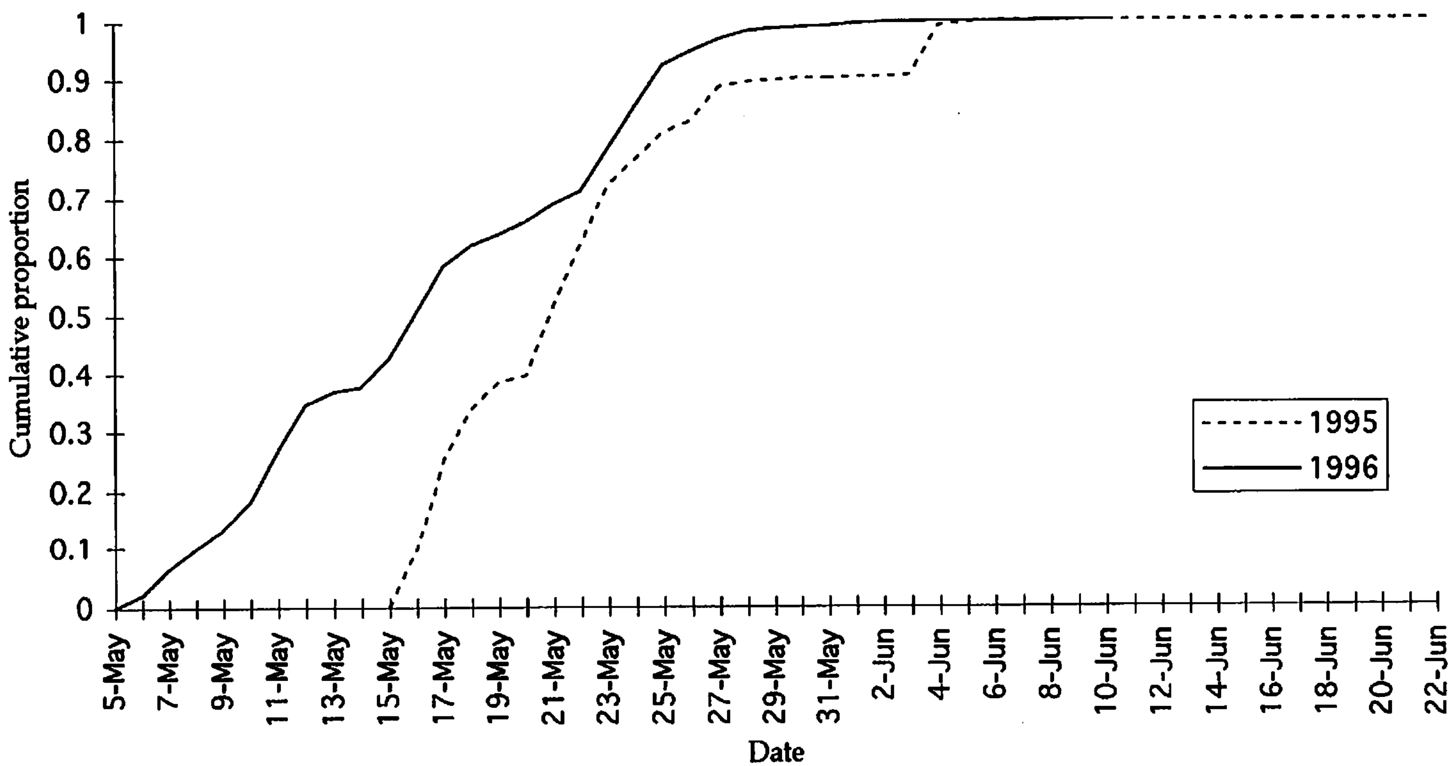


Figure 10. Cumulative proportion distribution for chinook salmon smolts captured at the lower site, 1995 and 1996.

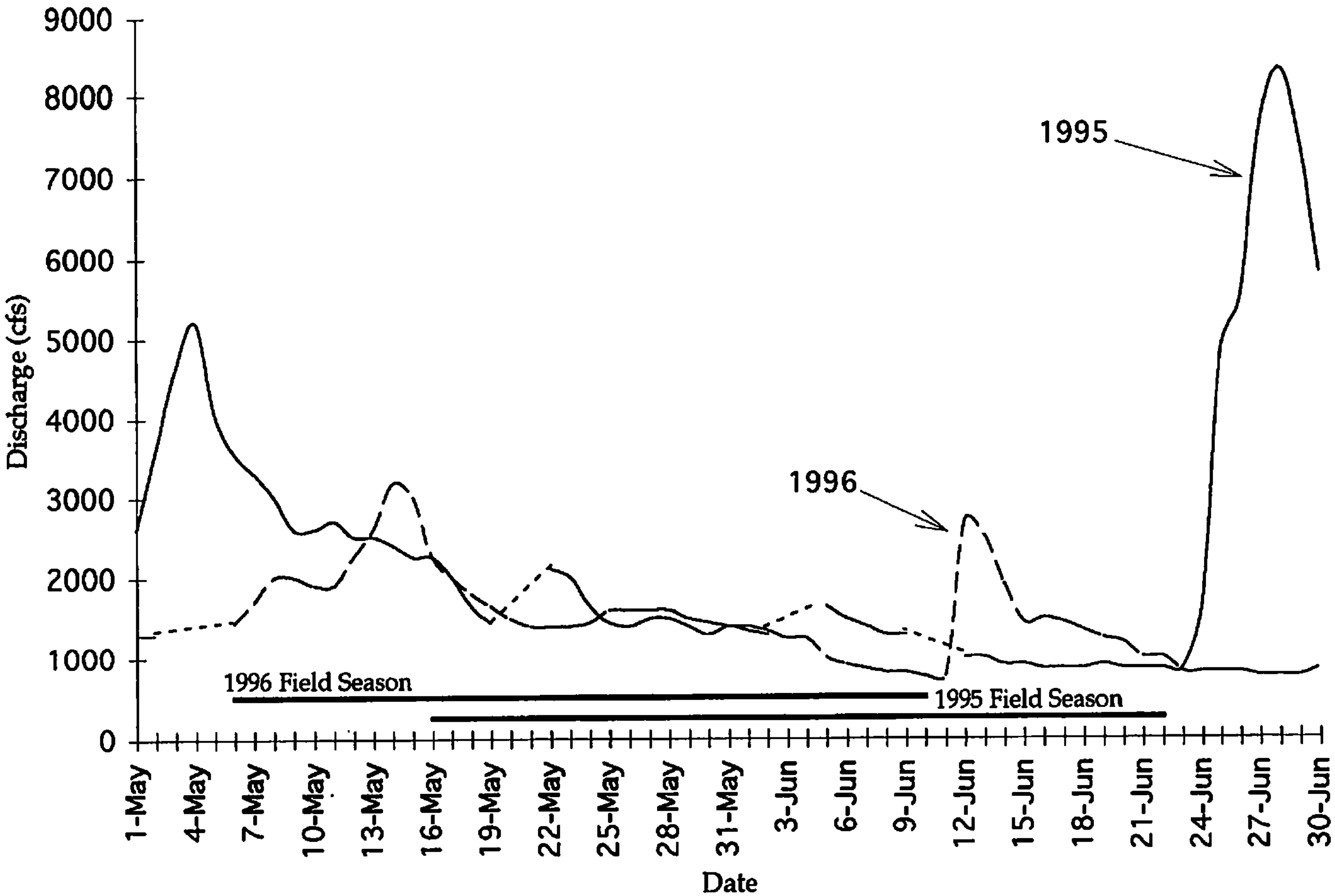


Figure 11. Discharge measured at the Chena River Dam (May and June, 1995 and 1996). The duration of the 1995 and 1996 field seasons are presented for reference. Dashed lines within the data indicate periods when no data were recorded.

Age-0 chinook were affected by this event but no attempt was made to quantify this effect. However, hundreds of age-0 chinook were observed in the floodway reservoir; over a fifteen minute period roughly 100 chinook were observed making their way back into the Chena River from the floodway once drawdown of the reservoir began. Extensive predation upon these fish by mew gulls (*Larus camus*) was observed.

Predation on chum fry by chinook smolts was observed in the recovery bucket following marking. No attempt was made to quantify this effect since the occurrence was rare enough to have little effect on assumptions or parameter estimates. Although predation was not a common occurrence, chum fry were noticeably more stressed when placed in the same bucket with chinook smolts than when placed in a separate bucket. When both species were present, chinook stayed at the bottom of the recovery bucket and chum fry maintained position at the top, a vulnerable position. When chinook were not present the chum fry would hold at the bottom of the recovery bucket. Stress was noted as this change in chum fry behavior.

Characteristic peaks in outmigration activity were observed for both species (Figures 7 and 8). There was generally at least one major peak and several minor peaks observed for each species in both years. Several variables, ranging from environmental to genetic or a combination of both, may be responsible for the observed peaks in outmigration activity. The relationship of temperature to CPUE is illustrated in Figures 12 and 13. The general trend indicates that water temperature rises throughout the field season and the CPUE (number of fish captured per hour) falls. As previously stated, discharge also differed substantially between 1995 and 1996 (Figure 11) and the relationship of variable

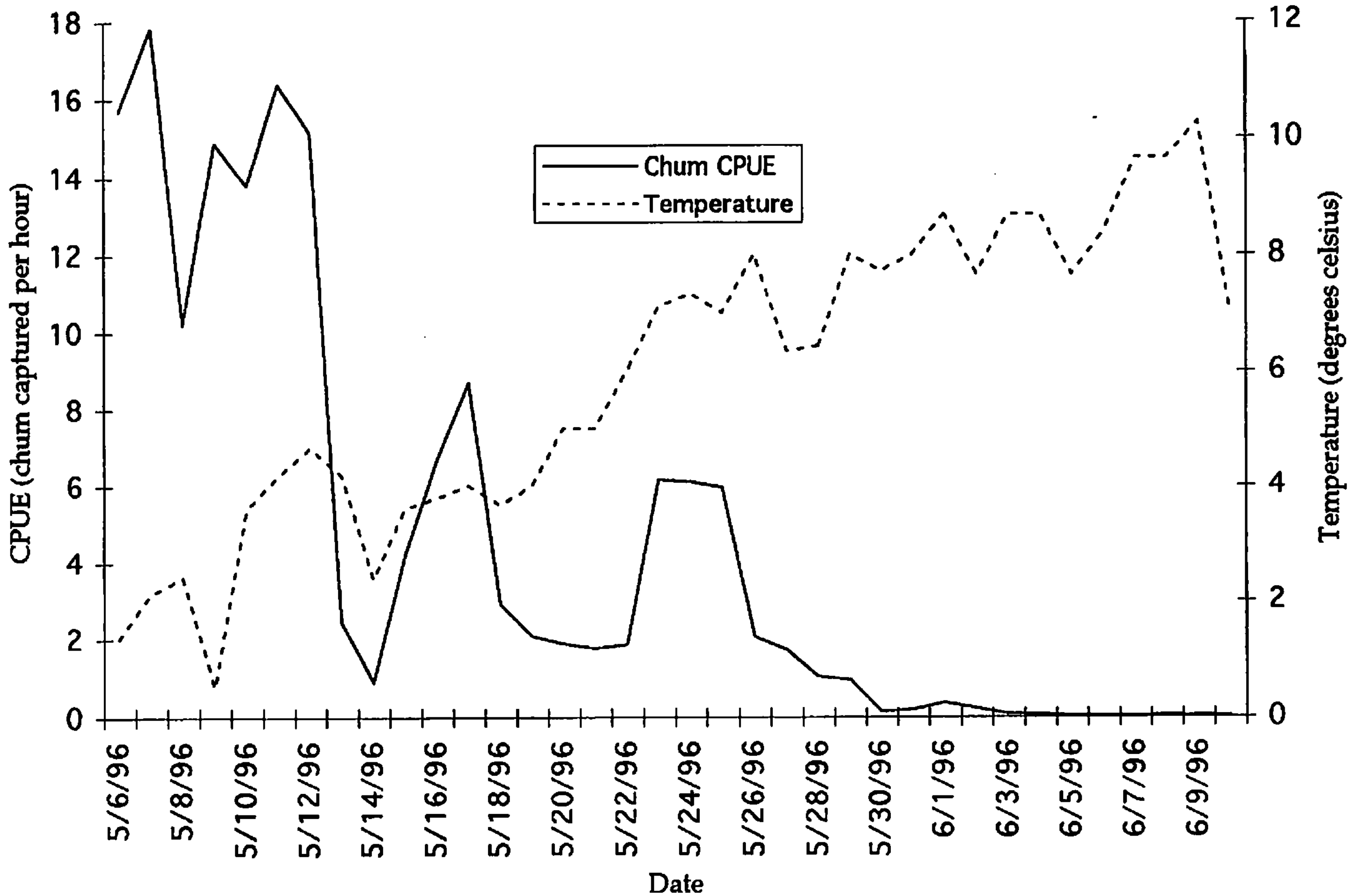


Figure 12. Temperature and CPUE for chum salmon fry at the lower site, 1996.

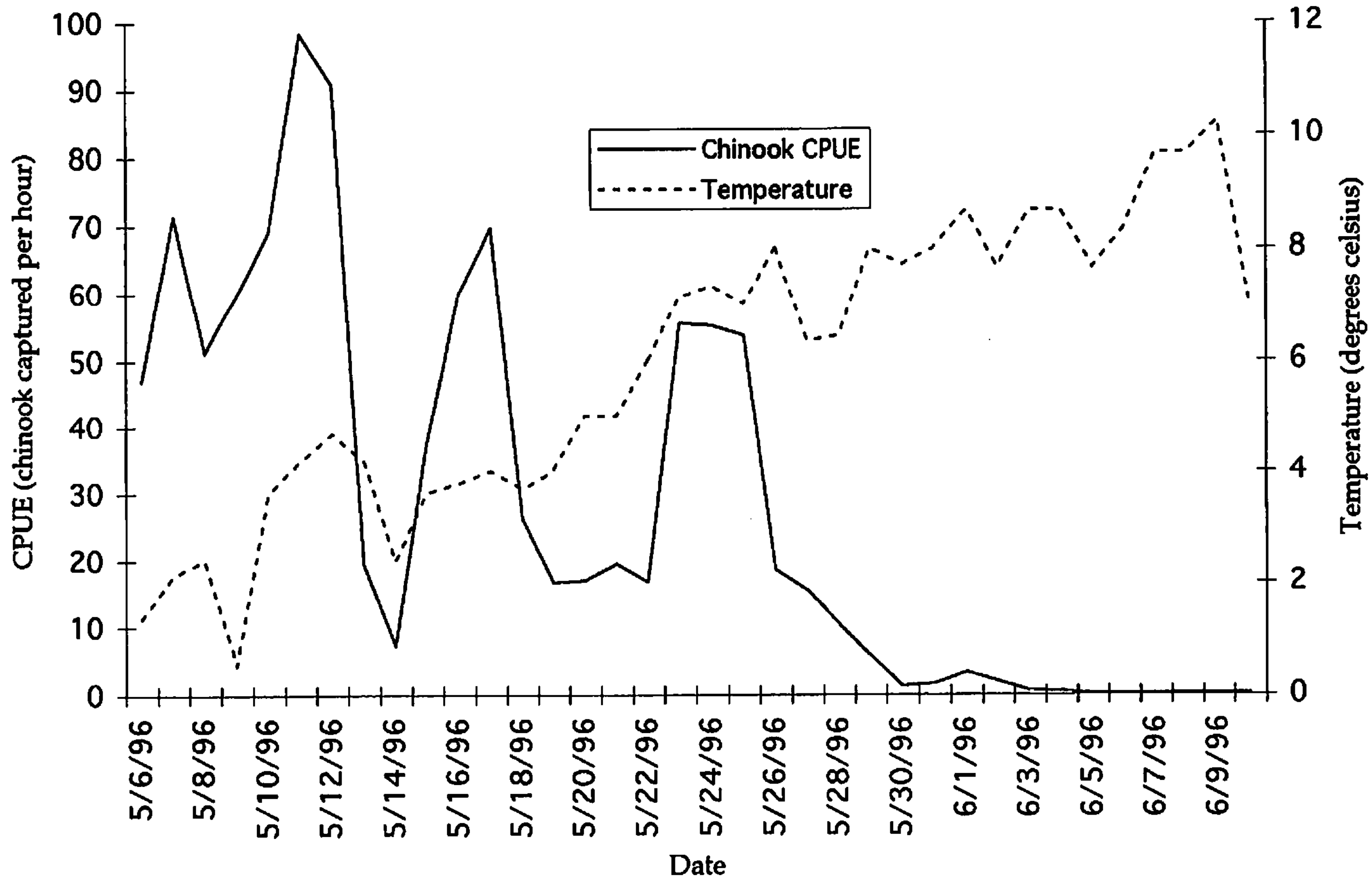


Figure 13. Temperature and CPUE for chinook salmon smolts at the lower site, 1996.

discharge to outmigration activity is shown in Figures 14 and 15: peaks in CPUE generally tend to occur on the rising limb of a discharge peak. The magnitude of these peaks is apparently dependent upon how advanced the outmigration is; later in the season the peaks are generally of smaller magnitude. The single apparent exception is with chum salmon from 1995 (Figure 14, top). As described earlier, this peak may be constituted of a large number of age-0 chinook.

Minor peaks in outmigration activity (diurnal variation) were noted within each day and are presented in Figure 16 for both 1995 and 1996. These minor peaks may represent a behavioral strategy by outmigrants, such as predator avoidance.

Catch Per Unit Effort

Data concerning the establishment of a long-term monitoring protocol based on three-hour trapping periods versus one-hour trapping periods is presented in Table 2. Three hour trapping periods appear to catch about three times as many fish as one hour trapping periods.

An attempt to standardize catch per unit effort (CPUE) was made over both field seasons. Because volume of water filtered by the traps is directly proportional to the amount of sampling time, CPUE measured in fish captured per hour was the most convenient measure of effort. The amount of time was standardized at one hour due to the observed catch rates and the number of fish that could be processed by a two person crew in this time period. An important assumption for these CPUE units is that discharge does not change significantly over one hour.

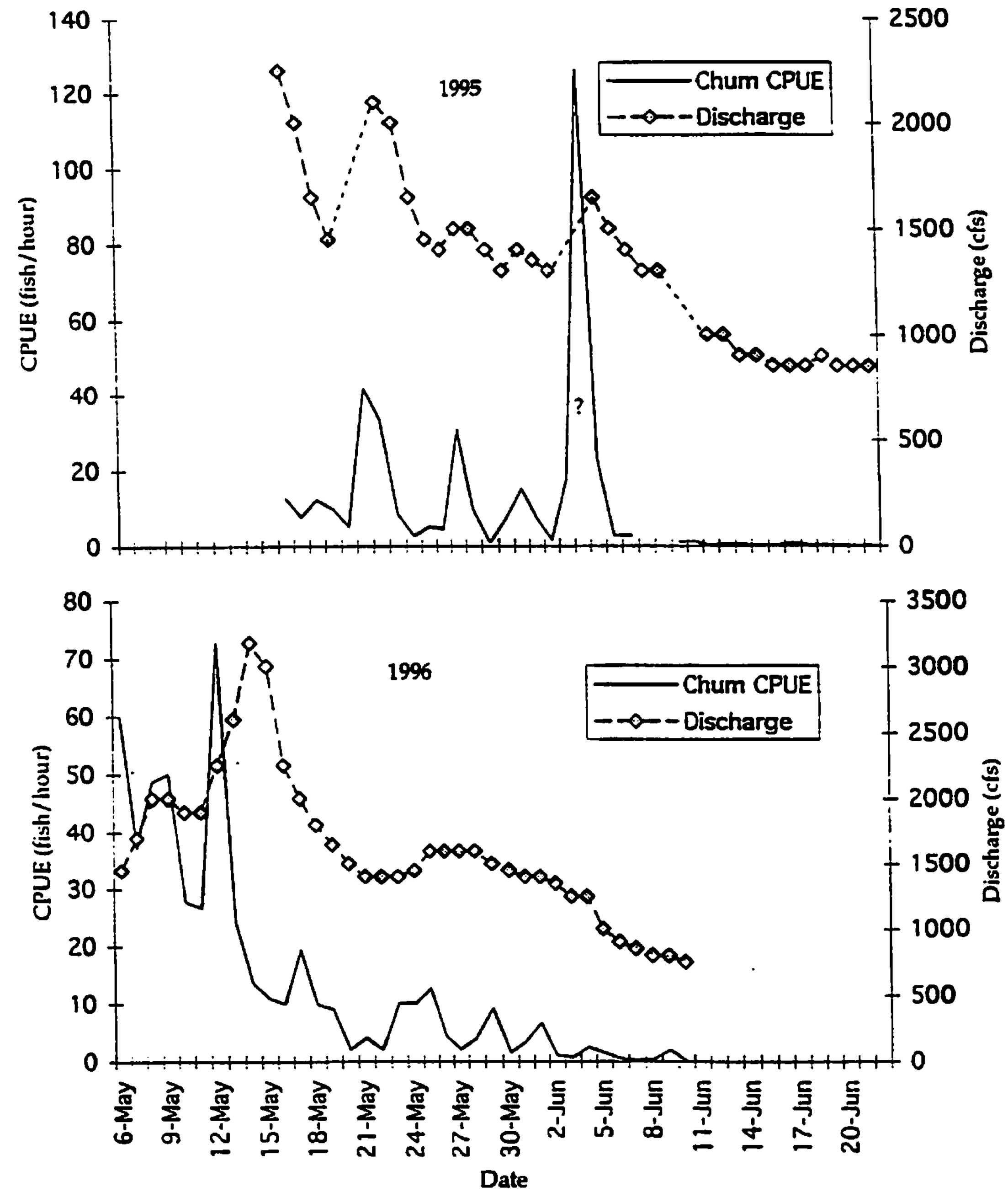


Figure 14. Discharge and CPUE for chum salmon fry, 1995 and 1996. The "?" symbol indicates that there may be a large number of age-0 chinook present in this peak (see text).

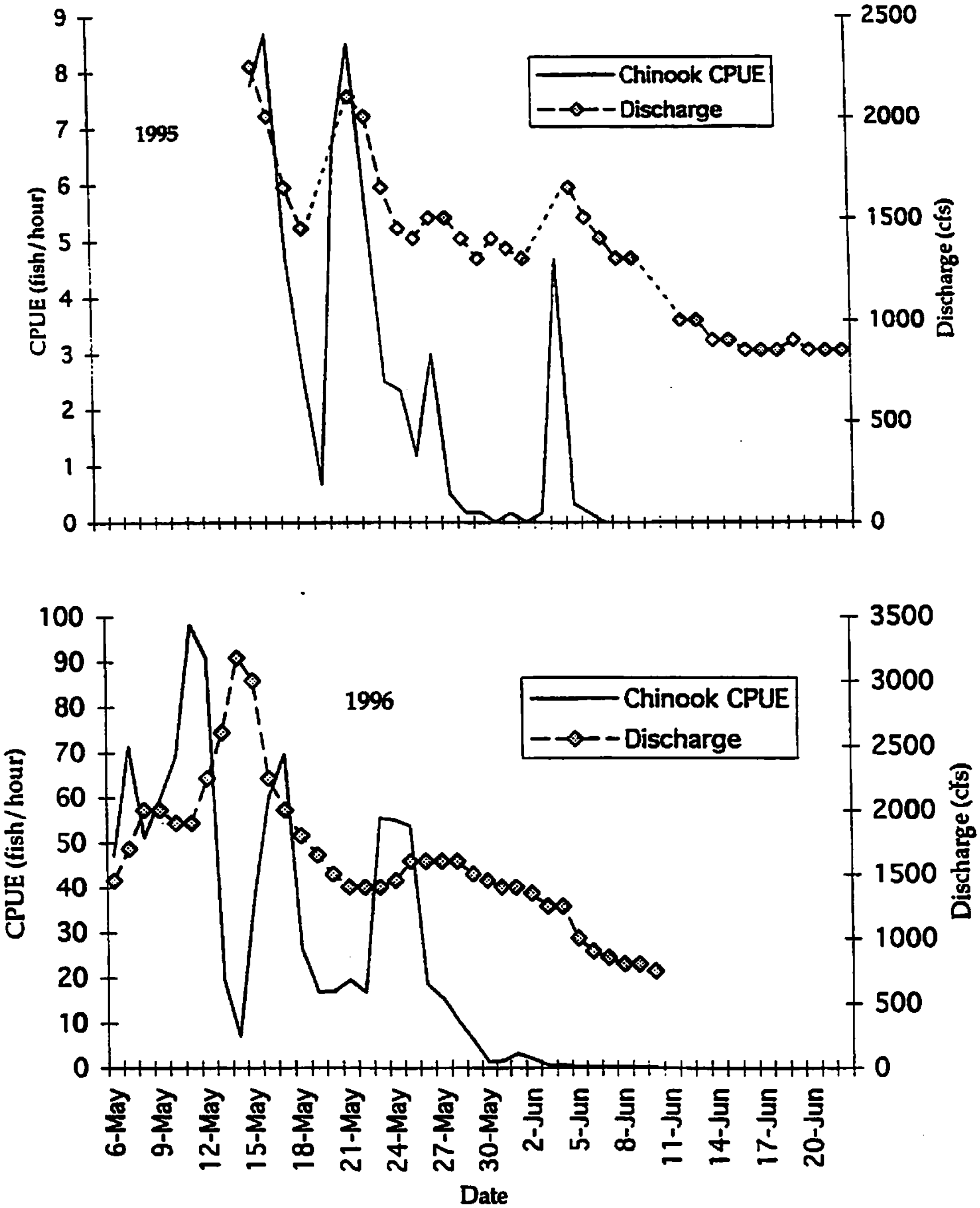


Figure 15. Discharge and CPUE for chinook salmon smolts, 1995 and 1996.

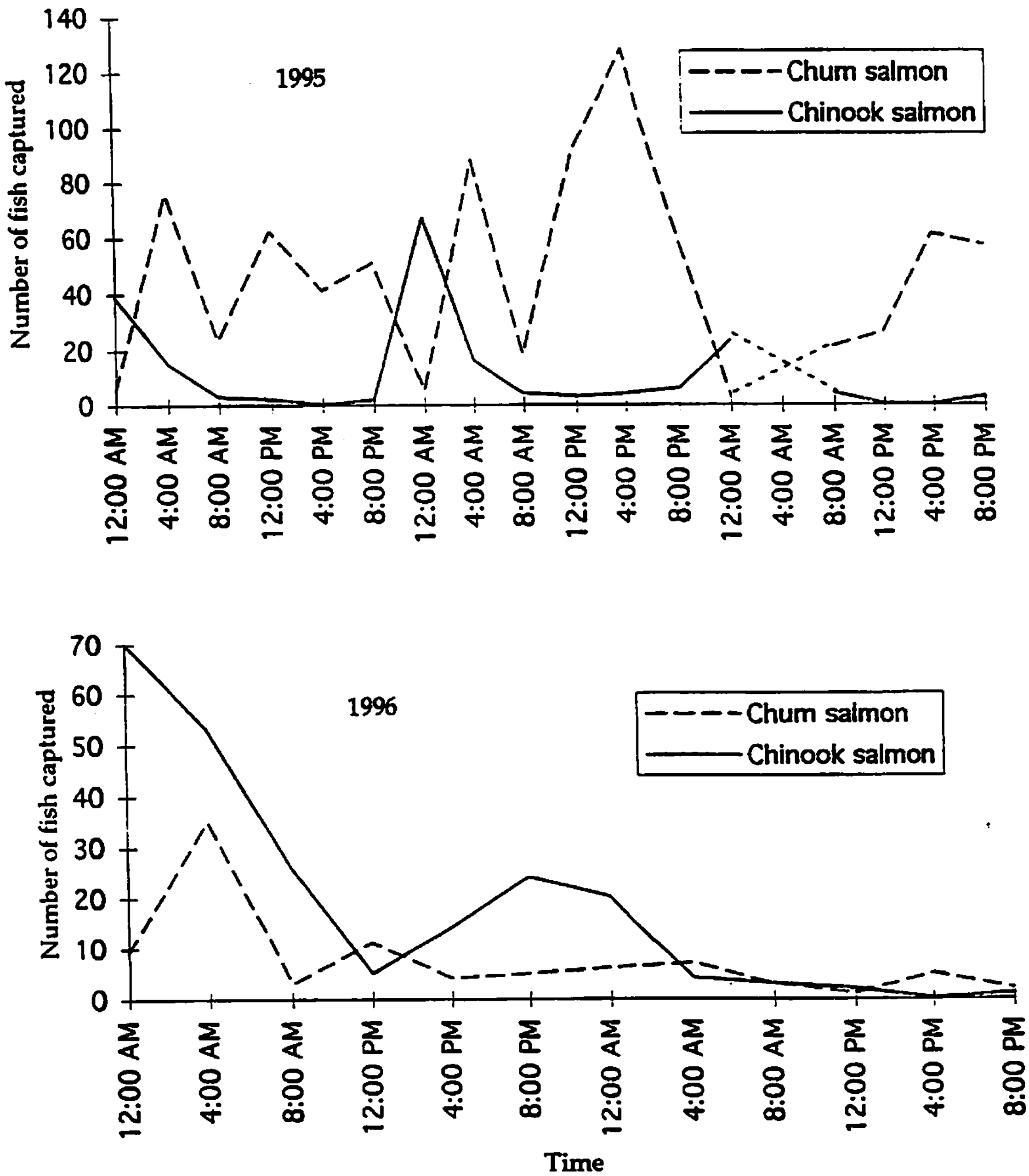


Figure 16. Diurnal capture rates for chum salmon fry and chinook salmon smolts. Actual sampling dates are May 10-12 (1995) and May 23 and May 28 (1996).

Table 2. No loss of efficiency was found when fishing the rotary screw trap every hour versus every three hours during periods of relatively low discharge (see Figure 8). May 23 and May 24 indicate a slight increase in discharge and thus a higher capture rate.

Date	Number of Hours Fished	Number of times Trap Emptied	Total Chinook Captured	Chinook Captured per Hour
5/20/96	9	3	152	17
5/21/96	11	11	214	20
5/22/96	9	3	150	17
5/23/96	9	9	498	55
5/24/96	9	3	494	55

Figures 17 and 18 show the relationship between CPUE (fish/hour) and discharge (m^3/second). In both of these figures there appears to be a range over which there is a linear relationship between CPUE and discharge, from 30 to 60 m^3/second for chum fry (Figure 17) and from 30 to 70 m^3/second for chinook smolts (Figure 18). This relationship deteriorates above and below these levels of discharge. The effect of discharge was removed from catch rate calculations in Figures 19 and 20 (Appendix 3) by plotting discharge against CPUE (fish captured per day per cubic foot of water filtered) to determine if discharge was masking other biological factors. The same relationship appears in Figures 19 and 20 as in Figures 17 and 18, therefore discharge was removed from consideration as a variable in CPUE calculations.

For each species, CPUE generally followed the same trend for both years: high in the early weeks and decreasing throughout the field season (Tables 3-7). Throughout both seasons and for both species the coefficient of variation tended to grow and the range of CPUE tended to narrow and become smaller (Tables 3-7).

Parameter Estimates

The number of recaptures in the 1996 field season was sufficient to calculate abundance and survival estimates for both chum and chinook outmigrants. The capture histories used to compute estimates for both chum and chinook salmon are given in Table 8. This provides a summation of the number of fish caught at each site over the entire 1996 field season. The parameter estimates, along with their related standard errors and 95% confidence intervals, are given in Table 9. The target population should be noted when interpreting these estimates. Since some spawning takes place below the dam, especially for chum salmon

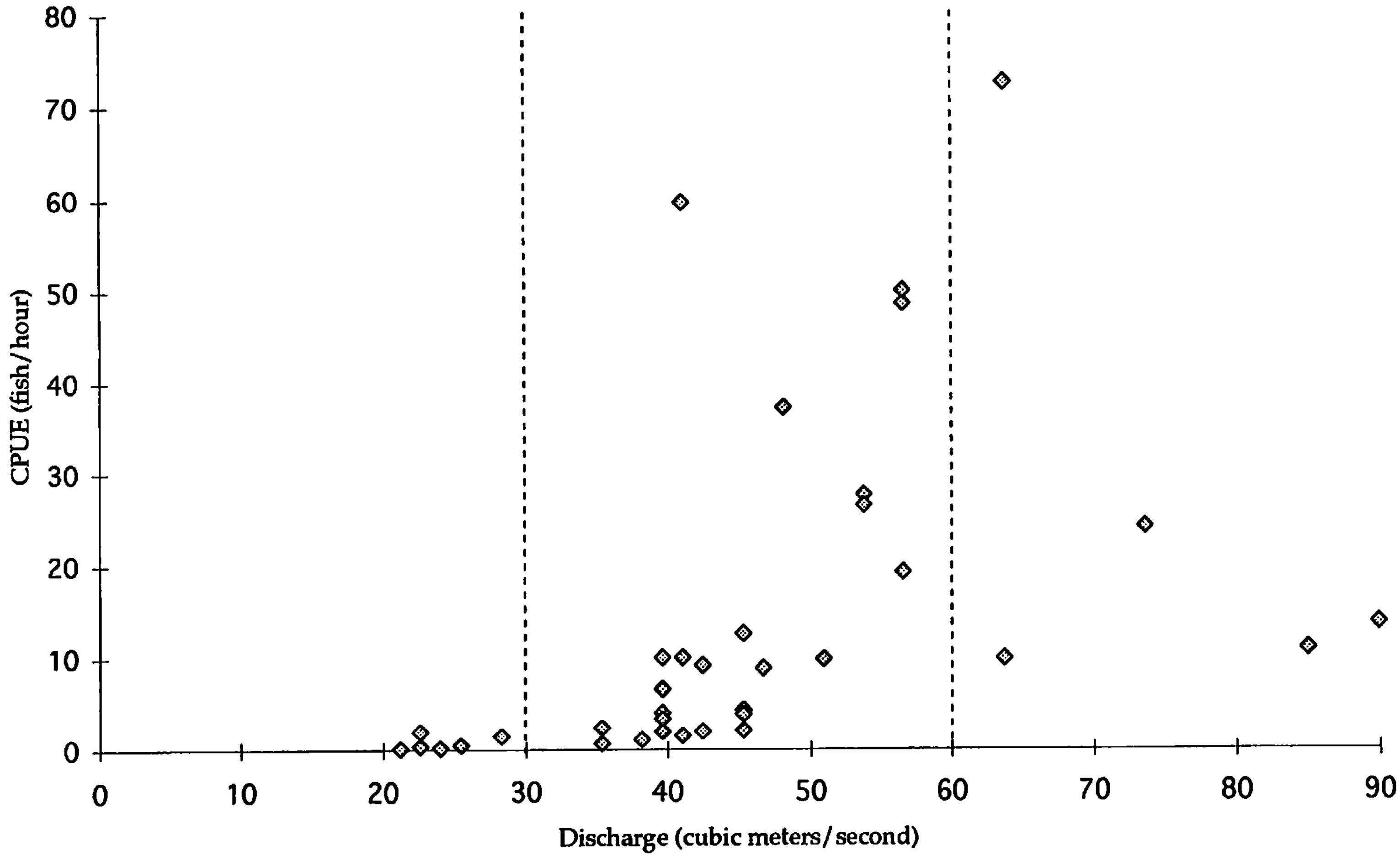


Figure 17. The relationship between CPUE and discharge for chum fry as measured at the lower site in 1996.

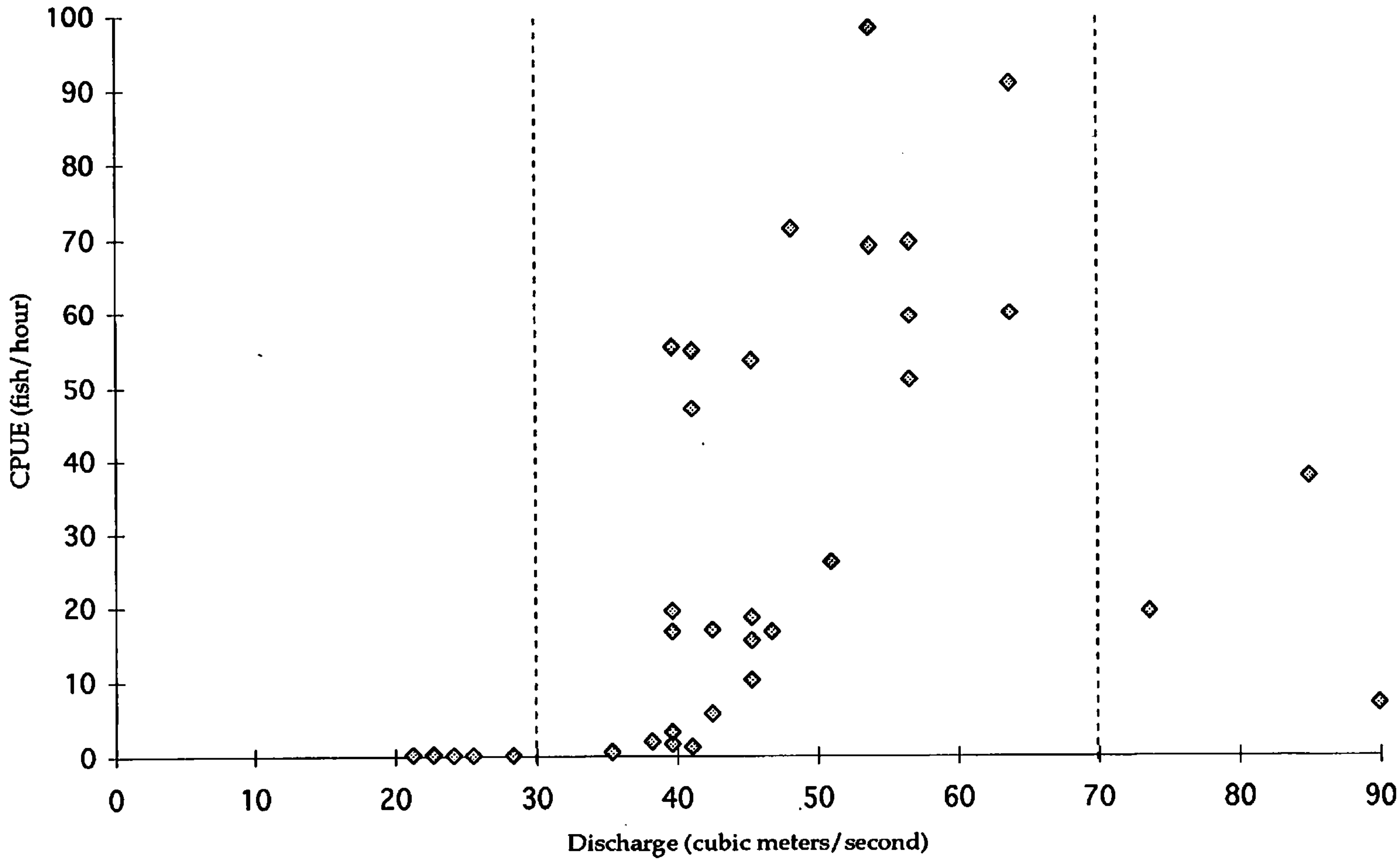


Figure 18. The relationship between CPUE and discharge for chinook smolts as measured at the lower site in 1996.

Table 3. Weekly mean CPUE (fish/hour) for chum fry and chinook smolt during the 1995 field season (upper site) with related statistics (N=number of hours sampled, SD=standard deviation, and CV=coefficient of variation).

	CPUE (chinook smolts/hour)				
	N	Mean	SD	CV	Range
Week 1	41	0.88	1.56	27.8	0 - 6
Week 2	41	0.20	0.56	44.6	0 - 3
Week 3	38	0.00	0.00	-	0 - 0
Week 4	26	0.00	0.00	-	0 - 0
Week 5	34	1.50	2.78	31.8	0 - 10
	CPUE (chum fry/hour)				
Week 1	41	11.95	18.88	24.7	0 - 88
Week 2	41	4.05	6.14	23.7	0 - 29
Week 3	38	3.18	4.24	21.6	0 - 17
Week 4	26	1.69	2.63	30.5	0 - 13
Week 5	34	4.65	6.09	22.5	0 - 25

Table 4. Weekly mean CPUE (fish/hour) for chum fry and chinook smolt during the 1995 field season (lower site) with related statistics (N=number of hours sampled, SD=standard deviation, and CV=coefficient of variation).

	CPUE (chinook smolts/hour)				
	N	Mean	SD	CV	Range
Week 1	38	5.37	6.01	18.2	0 - 20
Week 2	42	2.17	3.50	24.9	0 - 14
Week 3	42	0.79	2.31	45.4	0 - 12
Week 4	35	0.03	0.17	100.0	0 - 1
Week 5	61	0.00	0.00	-	0 - 0
	CPUE (chum fry/hour)				
Week 1	38	16.82	17.53	16.9	0 - 72
Week 2	42	8.81	13.42	23.5	0 - 63
Week 3	42	28.10	50.94	28.0	0 - 256
Week 4	35	1.43	1.96	23.2	0 - 8
Week 5	61	0.21	0.52	31.2	0 - 3

Table 5. Weekly mean CPUE (fish/hour) for chum fry and chinook smolt during the 1996 field season (upper site) with related statistics (N=number of hours sampled, SD=standard deviation, and CV=coefficient of variation).

	CPUE (chinook smolts/hour)				
	N	Mean	SD	CV	Range
Week 1	41	23.41	12.83	8.6	4 - 57
Week 2	47	9.72	8.22	12.3	1 - 33
Week 3	56	9.79	18.45	25.2	1 - 24
Week 4	63	2.41	5.33	27.8	1 - 7
Week 5	69	0.26	3.15	145.5	0 - 1
	CPUE (chum fry/hour)				
Week 1	41	17.41	11.40	10.2	4 - 48
Week 2	47	4.60	5.30	16.8	0 - 22
Week 3	56	2.02	3.90	25.9	0 - 4
Week 4	63	1.60	2.93	6.6	0 - 4
Week 5	69	0.32	1.16	43.8	0 - 1

Table 6. Weekly mean CPUE (fish/hour) for chum fry and chinook smolt during the 1996 field season (middle site) with related statistics (N=number of hours sampled, SD=standard deviation, and CV=coefficient of variation).

	CPUE (chinook smolts/hour)				
	N	Mean	SD	CV	Range
Week 1	52	13.02	9.84	10.5	1 - 53
Week 2	65	5.89	4.61	9.7	0 - 19
Week 3	66	5.55	11.31	6.0	0 - 21
Week 4	59	1.02	2.80	35.2	0 - 4
Week 5	72	0.36	1.53	50.1	0 - 2
	CPUE (chum fry/hour)				
Week 1	52	2.58	3.83	20.6	0 - 19
Week 2	65	1.25	1.98	19.7	0 - 11
Week 3	66	0.58	1.19	25.3	0 - 4
Week 4	59	0.97	3.75	49.6	0 - 16
Week 5	72	0.28	2.87	121.8	0 - 1

Table 7. Weekly mean CPUE (fish/hour) for chum fry and chinook smolt during the 1996 field season (lower site) with related statistics (N=number of hours sampled, SD=standard deviation, and CV=coefficient of variation).

	CPUE (chinook smolts/hour)				
	N	Mean	SD	CV	Range
Week 1	33	72.64	37.86	9.1	22 - 175
Week 2	59	34.12	30.72	11.7	2 - 165
Week 3	65	33.18	65.55	24.1	5 - 97
Week 4	61	5.67	16.26	36.7	0 - 33
Week 5	74	0.23	0.84	42.7	0 - 1
	CPUE (chum fry/hour)				
Week 1	33	45.55	34.36	16.4	7 - 144
Week 2	59	13.59	10.28	9.8	1 - 41
Week 3	65	6.37	12.83	25.0	1 - 20
Week 4	61	3.75	6.18	9.8	0 - 8
Week 5	74	0.89	2.99	39.0	0 - 4

Table 8. Capture histories for chum and chinook salmon, 1996. In capture histories, a "1" represents a capture and a "0" represents no capture (e.g., 101 represents captured at the upper and lower site, but not at the middle site).

Capture History	Number of Chum	Number of Chinook
100	1172	2097
010	329	1492
001	3002	6786
110	0	22
101	9	64
011	3	78
111	0	2

Table 9. Seasonal population estimates and survival probabilities and their respective standard errors and 95% confidence intervals for chum fry and chinook smolt on the Chena River, summer 1996.

Species	Population Size	Standard Error	95% Confidence Interval	Survival Probability	Standard Error	95% Confidence Interval
Chum	266,104	70,445	128,031- 404,177	0.135	0.0476	0.042-0.228
Chinook	171,952	13,066	146,342-197,561	0.713	0.1131	0.492-0.935

(Wuttig, Alaska Cooperative Fish and Wildlife Research Unit, personal communication), the reported estimates are only applicable to those outmigrants who have been exposed to the dam. Therefore, the estimates relate to progeny from adults spawning above the dam, not to the entire Chena River stock.

Model A′ from the program JOLLY was used to compute abundance estimates and model H1Phi from the program RELEASE was used to compute survival estimates. Recapture rates were too low in 1995 to calculate meaningful estimates (Appendix 4) mainly due to poor mark retention and the late start for data collection.

Discussion

Physical Factors Affecting Outmigration

A drastic difference between the number of chinook captured in 1995 and 1996 is apparent in Figure 8. Because the same trap and the same location were used each year, the difference may be primarily due to one of two reasons. Either we missed the peak of the chinook outmigration in 1995 or the 1996 run was more abundant than that of 1995. We may easily have missed the peak in 1995 because breakup occurred earlier (see the earliest peaks in discharge for each year, representing breakup, on Figure 11) due to the milder winter and the subsequent shallow freeze. Whether the 1996 year-class was exceptionally strong or not will be clearer with the addition of a third year of data following the 1997 field season. If the numbers captured in 1997 are similar to those from 1996, then we probably had a typical year-class size in 1996 and, apparently, a small year-class in 1995 (Figure 8). The disparity in numbers of chinook captured was not due to a steep learning curve in capture methods during the first season. The feasibility study allowed us to establish a standardized method for removing fish from the live box (see methods) and this method did not change the second year. In addition, the chum numbers were comparable over the same period for the two field seasons (Figure 7) indicating that it was not a learning curve effect. The chum capture numbers after June 1, 1995 are somewhat suspect due to the presence of age-0 chinook, mistakenly identified as chinook smolt, but it appears that the outmigration peak was missed in 1995.

The cumulative capture curves (Figures 9 and 10) indicate that our field seasons were of sufficient length, but more effort should have been concentrated on the beginning of the field seasons and slightly less towards the end. The same flattening of the curve that occurs with the later dates should also occur with the early dates if we were in fact sampling before most fish began their outmigration because very few fish would be outmigrating prior to breakup. There is a slight front-end flattening of the curve evident for the 1996 chinook salmon and 1995 chum salmon, but the other curves are not initially flat: sampling began well after the start of outmigration.

The 1995 field season was a "normal" year for Chena River discharge. Heavy snow early in the winter kept the ground from freezing too deep and the increase in stream flow associated with breakup (Figure 11) occurred during the first week in May. However, the 1996 field season was marked by a below average snowfall the previous winter. Without the usual insulating effect of snow on the ground, a deep freeze occurred and was the likely cause of the delayed high water event associated with breakup. Not only was the high water delayed until the second week in May, but it was of much less magnitude than that experienced in 1995.

The characteristic outmigration peaks in Figures 6 and 7 do not appear to be related to water temperature (Figures 12 and 13). Similar findings are reported by Flagg (1983) in his study of sockeye salmon outmigration; early outmigration appears to increase with increasing temperature, but as the temperature continues to increase through the season the number of outmigrants decreases. Additionally, there appears to be no relation between the peaks in temperature and the peaks in outmigration activity (Figures 12 and 13). However, peaks in outmigration activity do seem to be related to discharge. For both 1995 and 1996, increases in discharge generally were associated with an increase in the CPUE (Figures 13 and 14). This trend is consistent except for one instance with chinook salmon in 1996 (Figure 15); a peak occurred on May 17, during a period when discharge was decreasing.

Capture rates of chinook smolts appear to increase during the night and decrease during the day (Figure 16). This supports Williamson's (1984) findings of an increase in the number of outmigrants at night on the Chena River but does not necessarily prove that fish are not outmigrating during the daytime. Bendock (Alaska Department of Fish and Game, Soldotna, personal communication) found that salmon smolts were capable of avoiding capture with rotary screw traps in the daylight while outmigrating on Deep Creek, Alaska. Roper and Scarnecchia (1996), using a rotary screw trap, found that wild chinook smolts outmigrate during periods of greatest darkness and remain stationary during daylight hours. Hartman et al. (1982) and McMenemy and Kynard (1988) both report a nighttime migration of age-0 chinook salmon. Healey (1991) reports that the majority of chinook salmon outmigrate at night, but in systems with lengthy migrations, daytime outmigration is not uncommon. Chum salmon do not follow such patterns (Figure 16) and this is probably due to their inability to navigate in the river as well as chinook salmon. Their small body size apparently makes them incapable of holding in the river and their downstream movement is therefore more influenced by discharge. McDonald (1960) reported that chum salmon fry in the Skeena River outmigrate nocturnally where the migration distances are short, but they outmigrate during all periods of the day when migration distances are great. Direct observations and recaptures of marked fish at the upper site in 1995 indicate that Chena River chum appear to be holding when possible during daylight hours and, when they are small, only move when forced to during periods of high discharge.

Sampling at night maximizes the chinook capture rate while maintaining the chum capture rate.

Chum salmon holding and feeding in estuarine areas is a common phenomenon (J. Helle, National Marine Fisheries Service, Auke Bay, Alaska, personal communication) and has been observed in many river systems (Murphy et al. 1988), but little is known about chum fry holding in rearing areas in lengthy systems such as the Yukon River tributaries. Because chum fry exhibited statistically significant growth in the Chena River between the upper and lower capture sites (Daigneault 1997), it is evident that chum fry are holding and feeding in rearing areas to attain greater size prior to outmigration. Attaining a greater size is an advantageous adaptation in this river system presumably because larger fish are better able to avoid predation. To what extent this feeding occurs in similar systems with populations of chum salmon, such as the Amur River in Russia and China (Salo 1991), is unknown and may be of interest for future studies.

Catch Per Unit Effort

Based on the data presented in Table 2, there is no discernible loss of efficiency when the rotary screw trap is fished for three hours as opposed to the standard one hour used through most of this study. Roper and Scarnecchia (1996) reported no change in efficiency with a rotary screw trap running for 24 hours. However, it should be noted that these data represent fishing during periods of relatively low flow. Periods of high flow in the Chena River and the associated increase in debris load characteristic of this river significantly affect the amount of time a trap can be left unattended. On what was scheduled to be the last day of the 1996 field season, June 11, the debris load was so high that the trap would not run for more than 15 minutes without becoming impassable to fish. Trapping had to be called off for the night due to extensive fish injury and death due to impingement of fish upon debris caught in the trapping cone. At one point the clogging of the trap became so acute that water was flowing backwards from the livebox into the trapping cone.

As previously mentioned, CPUE is standardized as the number of fish captured per hour. CPUE is a hydrographically-related phenomenon, but due to the inconsistencies with it's relation to discharge (1996 chinook, Figure 15) the exact nature of this relationship cannot yet be determined. Generally speaking, however, an increase in discharge during the outmigration period results in an increase in the number of fish outmigrating. Several reasons may account for this fact. First, with an increase in discharge there is a corresponding increase in the turbidity of the Chena River. It can be transformed from a clear-flowing river to a brown, debris-laden river in less than a day, given sufficient precipitation or breakup conditions. The resultant murky waters provide excellent cover for outmigrants from predation by both fish (mainly Arctic grayling *Thymallus arcticus*) and birds (mainly Mew gulls *Larus camus*). It is already established that the Chena River salmon stocks concentrate their outmigration at night, presumably to avoid predation (Williamson 1984), so the turbid water associated with increased discharge adds an extra measure of protection for the outmigrants.

A second reason that increased discharge results in an increase in CPUE is due to the flushing effect of high water. Chum salmon, in particular, cannot hold position in high velocity waters typical of increased discharge (Salo 1991). Observations from both field seasons indicate that outmigrants tend to hold in back-eddies and slow pools to feed and attain greater body size prior to beginning outmigration. Increased discharge flushes fish out of slow-water feeding areas, forcing them downstream.

Figures 17 and 18 have several implications for the effectiveness of the rotary screw traps. Over the middle range of discharge, it appears that discharge is proportional to CPUE. As discharge increases CPUE increases in a linear fasion. However, below a discharge of 30 m^3/second the trap appears to be ineffective at capturing fish (Figures 17 and 18), possibly due to trap avoidance by fish at low water velocity. At high discharge, above 60 m^3/second for chum fry and above 70 m^3/second for chinook smolts, the trap cannot maintain high CPUE (Figures 17 and 18). This could be the result of reduced trap efficiency caused by debris blocking the trapping cone or fish outmigrating outside of the thalweg to reduce the potential of injury from debris.

It was expected that the average CPUE would drop throughout the season as it did (Tables 3-7) because there are fewer fish available for capture later in the outmigration event. An interesting finding is the general increase in coefficient of variation (CV) per week through each season. Since CV is a measure of the standard error relative to the sample size, the increasing trend is probably due to fish outmigrating in pulses later in the season rather than as one, continuous group as they do earlier in the season. High catches are more sporadic later in the season because the majority of fish have already outmigrated, and this sporadic migratory activity causes an increase in capture variability.

Parameter Estimates

Model A′ from JOLLY was selected to calculate the abundance estimates for the Chena River chum and chinook salmon outmigrants for two reasons. First, the model selection algorithm within the software chose this model. Second, Model A' is the Jolly-Seber "death only" model (Pollock et al. 1990) which means that for the area being studied only deaths are allowed, no births. This is a valid assumption for our study because we are low enough in the Chena River to avoid the main salmon spawning grounds. Most chinook spawn well above all study sites and few chum spawn in the roughly 16 km between the upper and lower trapping sites.

Model H1Phi from RELEASE was selected to calculate survival estimates for the Chena River salmon stocks for several reasons. First, the model selection algorithm within the software chose this model. Second, this study has an acute treatment effect (i.e. the dam only "occurs" between the first two sites). If we were studying a chronic effect, such as a series of dams along the river, models H2Phi or H2p would be more suitable (Burnham et al. 1987). With an acute treatment effect and no new animals released into the study area after the first trapping site (i.e. no births), H1Phi is described by Burnham et al. (1987) as "by far [one of] the most useful models."

At this point, the estimates reported in Table 9 have little utility aside from the fact that we now have an estimate of the number of juvenile salmon exposed to the Chena River Dam. The original purpose of this study was to make comparisons of survival between event and non-event years for both salmon species. However, both the 1995 and 1996 field seasons had no flood control event during the period of salmon outmigration. Therefore, these numbers will serve as a baseline for the 1997 season should a flood occur.

There is bias associated with the parameter estimates, but it has been minimized by defining the target population as the number of fish exposed to the dam. If we were attempting to estimate abundance and survival for all juvenile salmon in the Chena River our abundance estimates would be too low because some adults are know to spawn below our sampling sites (Wuttig, Alaska Cooperative Fish and Wildlife Research Unit, personal communication). The effect of bias in survival estimates between the sampled and target population is not known. Any further bias is due to violation of the assumptions given above for sampling methods.

Several investigations have addressed the effect of bias on estimates of abundance and survival. If the validity of the four assumptions is in question, the effects of the related bias must be understood. The effects of the first assumption, heterogeneity of capture probability, are well studied (Pollock et al. 1990). "If certain individuals are more likely to be captured than others and the differences persist throughout the mark-recapture experiment, then the marked fish in the population will consist mainly of those individuals with higher capture probabilities" (Pollock et al. 1990). This will lead to a negative bias in abundance and a slight negative bias in survival probability (Carothers 1973 and Gilbert 1973). There was no evidence over the course of this project that this assumption was violated.

The second assumption, equal probability of survival for marked fishes following release, is important in survival estimates (Pollock et al. 1990). If a large number of marked fish die before reaching the next sampling site a large negative bias will occur in the survival estimate. This bias may be partially responsible for our low estimates of survival for both species, especially chum salmon. Because our marking protocol was still being established fish were observed closely in the 1995 field season for mortality following marking. However, not as much attention was given to this observation in 1996. It is possible that some outmigrants suffered greater mortality after marking than others due to stresses placed upon them in the marking procedure.

The assumption of no tag (caudal fin clip) loss, if violated, can cause negative bias of survival estimates but has little effect on abundance estimates (Arnason and Mills 1981). I believe overlooking caudal fin clips was a major source of bias for chum fry. Chum fry caudal fins are extremely small compared to chinook smolt caudal fins, and their clear coloration makes marks upon them difficult to detect. This was probably not a significant sourse of bias in the chinook smolt survival estimate due to the large size of the caudal fin, upon which marks were easily visible even in poor light.

The assumption of instantaneous samples and immediate release is not completely possible in practical field conditions, but possible effects can be minimized. If this assumption is violated, it can result in the same type of bias as that associated with tag loss because, in effect, tagged animals are lost from the population by not releasing them immediately (or soon thereafter) upon capture. Bias due to this assumption was minimized by implementing relatively short sample periods and releasing fish as soon as possible following recovery from the anesthetic; it is believed to have little effect on the parameter estimates.

A final, implied assumption mentioned by Pollock et al. (1990) is that all emigrations from the study area are permanent. Although the effects of violating this assumption have not been studied, Pollock et al. (1990) state "that the bias induced could be serious" and negative. This may be a significant source of bias in our estimates. During the 1995 field season many fish were observed swimming upstream, above the trap, following release. This phenomenon was not observed as often during the 1996 field season because the upper site trap was moved to an area with greater sustained discharge. Because there is no information on how serious this bias may be, the estimates presented here may be significantly affected.

Recommendations

Based on my findings from two years of experience studying chum and chinook outmigrants on the Chena River, there are several recommendations I would like to make for future studies.

1. A sampling design should be in place to quantify the extent of straying of outmigrants into the floodplain (Figure 1) during a flood event. This will be a difficult task due to the magnitude of the reservoir that forms and the area in which it forms. This sampling method must be capable of trapping fish in areas with significant submersed terrestrial vegetation. During the brief flood event experienced following the 1995 field season, baited minnow traps were set out in an attempt to capture the trapped age-0 chinook, but we had no success. Due to success with this technique for capturing age-0 chinook in the Kenai River (Bendock, Alaska Department of Fish and Game, personal communication), this technique remains promising and may be successful if more traps were to be used (only ten traps were set in 1995).
2. A clearer understanding of where the fish are outmigrating in the river is needed. Throughout this study it was assumed that the fish are following the thalweg. During feasibility work the traps were fished side-by-side and the trap that was located in the swifter water always captured more fish. However, it is unknown at which depth the majority of the fish are outmigrating. Although we captured more chinook at night, we do not know if this is because they were

not moving during the day or if they were simply moving deeper in the water column to avoid predation and therefore missing the trap. A trap could possibly be placed on the river bottom to detect movement under the rotary screw traps and inclined plane trap. This trap could be used in conjunction with a short-term monitoring program using Bismarck Brown Y dye as a mark. Fish could be transported a short distance upstream and released, effectively forcing them to move past the traps within a short time period following release. Capture rates could be compared for each trap during different time periods throughout the day.

3. Low numbers of fish were captured at the middle site and it needs to be determined if this was due to location or the inclined plane trap. The inclined plane trap should be fished at the lower site for at least a week during the 1997 field season to answer this question. If it is found to be a trap effect, capture rates of chum must be improved so that more meaningful estimates of abundance and survival can be made next year. One possibility for increasing the capture efficiency with the inclined plane trap is to install plastic fencing on the front of the trap to funnel fish toward the opening. Although debris may cause significant problems with this setup, it may be worthwhile if it significantly increases capture rates. If the inclined plane trap shows higher capture rates when fished at the lower site, indicating that the site was the reason for the low numbers in 1996, then consideration needs to be given to moving the middle site. The trap cannot be moved too far due to the positioning of the lower site and

the dam, but there are several promising areas located within one riverbend downstream that may produce higher capture rates.

4. Sampling should begin as early as possible following breakup in order to minimize the number of missed fish. Nets could be placed under the ice near the study sites to detect fish movement, or nets could be placed in open sections of the Chena River in Fairbanks (downstream from the power plant) to detect movement of outmigrants. Using Figures 9 and 10 as a reference, a flattening of the curve should be apparent for the early dates as well as for the latter dates (see discussion).
5. Length of trapping sessions may be standardized at 3 hours, instead of the 1 hour periods we used exclusively in 1995, only during periods with low debris load. Allowing rotary screw traps to fish for this longer period of time with large amounts of debris in the water will lead to a loss of efficiency due to clogging and the eventual stoppage of the trapping cone. Inclined plane traps face the same clogging problem and should therefore be fished on the same schedule as the rotary screw traps.
6. If the study is to be continued at this level of intensity in the future, trapping should continue to be concentrated at night. Based on our diurnal experimentation (Figure 16), chinook salmon numbers are consistently higher during the darker hours and chum salmon numbers seem to remain at relatively constant levels throughout the day. Therefore, high capture rates of both chum and chinook salmon can be maintained by fishing at night.

7. Juvenile outmigrants should remain separated during the marking and examination process due to predation on chum salmon by the chinook salmon. Although the effect was not quantified, several chinook were observed feeding upon chum when both species were left in the recovery bucket together. The chum fry are subjected to undue stress when held with chinook smolts. I do not believe this to be a significant source of bias in survival rate estimates because we rarely mixed species in recovery buckets, but it could become a significant factor if this protocol is not followed.

References

Arnason, A.N. and K.H. Mills. 1981. Bias and loss of precision due to tag loss in Jolly-Seber estimates for mark-recapture experiments. Canadian Journal of Fisheries and Aquatic Science 38: 1077-1095.

Arnold, D.E. 1965. Marking fish with dyes and other chemicals. United States Fish and Wildlife Service, Technical Paper 10, Washington, D.C.

Bilton, H.T. 1988. The body area and size that chinook, coho, and chum salmon fry first form their scales. Canadian Technical Report of Fisheries and Aquatic Sciences. Number 1632.

Burnham, K.P., G.C. White, C. Brownie, and K.H. Pollock. 1987. Design and analysis methods for fish survival experiments based on release-recapture. American Fisheries Society Monograph Number 5. 437 pages.

Carothers, A.D. 1973. The effects of unequal catchability on Jolly-Seber estimates. Biometrics 29: 615-630.

Daigneault, M.J. 1997. Health and condition of outmigrating juvenile chinook and chum salmon near the Chena River Dam, Alaska. Masters of Science thesis. University of Alaska Fairbanks.

Ewing, R.D., B.P. McPherson, and T.D. Satterthwaite. 1990. Effects of varied rearing temperatures and feeding regimes on retention of Bismarck Brown Y stain in alevins of Chinook salmon. The Progressive Fish Culturalist 52: 231-236.

Faurot, M.W. 1989. Habitat utilization by juvenile pink and chum salmon in upper Resurrection Bay, Alaska. United States Fish and Wildlife Service Technical Report EL-89-17.

Flagg, L.B. 1983. Sockeye salmon smolt studies - Kasilof River, Alaska 1981. Alaska Department of Fish and Game Division of Fisheries Rehabilitation, Enhancement, & Development Technical Data Report Number 11.

Fraley, J.J. and P.T. Clancey. 1988. Downstream migration of stained kokanee fry in the Flathead River system, Montana. Northwest Science 62(3): 111-117.

Fry, D.H. Jr. 1961. Some problems in the marking of salmonids. Pacific Marine Fisheries Commission Bulletin 5: 77-83.

Gilbert, R.O. 1973. Approximations of the bias in the Jolly-Seber capture-recapture model. Biometrics 29: 501-526.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life Histories. University of British Columbia Press. Vancouver, British Columbia.

Hartman, G.F., B.C. Andersen, and J.C. Scrivener. 1982. Seaward movement of coho salmon (*Oncorhynchus kisutch*) fry in Carnation Creek, an unstable coastal stream in British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 39: 588-597.

Healey, M.C. 1991. Life history of chinook salmon. Pages 311-393 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver.

Johnsen, B.O. and O. Ugedal. 1988. Effects of different kinds of fin-clipping on over-winter survival and growth of fingerling brown trout, *Salmo trutta* L., stocked in small streams in Norway. Aquaculture and Fisheries Management 19: 305-311.

McDonald, J. 1960. The behaviour of Pacific salmon fry during their downstream migration to freshwater and saltwater nursery areas. Journal of the Fisheries Research Board of Canada 17: 655-676.

McMenemy, J.R. and B. Kynard. 1988. Use of inclined-plane traps to study movement and survival of Atlantic salmon smolts in the Connecticut River. North American Journal of Fisheries Management 8: 481-488.

Mears, H.C. and R.W. Hatch. 1976. Overwinter survival of fingerling brook trout with single and multiple fin clips. Transactions of the American Fisheries Society 6: 669-674.

Neter, J., W. Wasserman, and M.H. Kutner. 1990. Applied Linear Statistical Models - Regression, Analysis of Variance, and Experimental Designs. Third edition. Richard D. Irwin, Inc. Homewood, Illinois.

O'Grady, M.F. 1984. The effect of fin-clipping, floy tagging and fin-damage on the survival and growth of brown trout, *Salmo trutta L.*, stocked in Irish lakes. Aquaculture and Fisheries Management 15: 49-58.

Pauley, G.B. and D.A. Troutt. 1988. Comparison of three methods of fluorescent dye application for marking juvenile steelhead. Transactions of the American Fisheries Society 117 (3): 311-313.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs, number 107. 97 pages.

Raymond, H.L. 1979. Effects of dams and impoundments on migrations of juvenile Chinook salmon and steelhead from the Snake River, 1966-1975. Transactions of the American Fisheries Society 108: 505-529.

Roper, B. and D.L. Scarnecchia. 1996. A comparison of trap efficiencies for wild and hatchery age-0 chinook salmon. North American Journal of Fisheries Management 16: 214-217.

Salo, E.O. 1991. Life history of chum salmon. Pages 231-310 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver.

Scully, R.J. and E. Buettner. 1986. Smolt condition and timing of arrival at Lower Granite Reservoir. Annual report to the Bonneville Power Administration, Contract Number DE-AI79-83BP-11631.

Sims, C.W. and D.R. Miller. 1982. Effects of flow on the migratory behavior and survival of juvenile fall and summer Chinook salmon in John Day Reservoir. NOAA, NMFS, NWAFC, Seattle, WA. Annual report to the Bonneville Power Administration, Contract Number DE-AI79-81BP-27602.

Thedinga, J.F., M.L. Murphy, S.W. Johnson, J.M. Lorenz, and K.V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14: 837-851.

Todd, G.L. 1994. A lightweight, inclined-plane trap for sampling salmon smolts in rivers. Alaska Fishery Research Bulletin 1(2): 168-175.

Ward, F.J. and L.A. Verhoeven. 1963. Two biological stains as markers for sockeye salmon fry. Transactions of the American Fisheries Society 92: 379-383.

Williamson, D. 1984. Chena River salmon outmigration studies, 1981-1983. Final Report. United States Fish and Wildlife Service. 34 pages.

Appendix 1: Capture Histories

Since there are three trapping sites in the study, there are $2^3 = 8$ possible capture histories. These are summarized in the following table, along with the assumptions necessary to quantify them and possible effects on parameter estimation. All capture histories (excluding 0-0-0) must be represented for program JOLLY (Pollock et al. 1990) to produce an iterative solution, therefore RELEASE is used to estimate survival.

Capture history	Remarks
1-1-1	Fish caught at all three trapping sites. This provides the most information, allowing estimates of survival between sites 1 and 2 and population estimates. High capture probabilities must be maintained.
1-0-0	Fish caught only at site 1. Does not allow estimates of survival or abundance alone, but provides additional information for estimates.
0-1-0	Treatment fish caught only at site 2. Does not allow estimates of survival or abundance alone, but provides additional information for estimates.
0-0-1	Treatment fish caught only at site 3. Does not allow estimates of survival or abundance alone, but provides additional information for estimates.
1-1-0	Fish caught at both site 1 and 2; allows an estimate of population size between these two sites. Fin clips from site 1 must be recognized.
1-0-1	Fish caught at site 1 and 3, but not at site 2. This is the statistic (z_2) used directly in the computation of survival rate between sites 1 and 2 (Pollock et al. 1990). Also used for calculation of recruitment.
0-1-1	Treatment fish caught at both sites 2 and 3; allows estimate of population size between these two sites. Fin clips from site 2 must be recognized.
0-0-0	An unknown number representing fish never caught.

Appendix 2: Non-target Species

Appendix 2 lists non-target species captured in the rotary screw traps during the 1995 field season and both the rotary screw traps and the inclined plane trap (middle site) during the 1996 field season. No non-target species were recorded at the upper site in 1995. Little undo stress upon chum fry or chinook smolts due to the presence of these non-target fishes was observed; the presence of non-target species is not believed to be a significant source of negative bias in survival estimates.

Species	1995	1996		
	Lower Site	Lower Site	Middle Site	Upper Site
Arctic Lamprey (*Lampreta japonica*)	31	17	31	30
Lake Chub (*Couesius plumbeus*)	12	9	0	2
Arctic Grayling (*Thymallus arcticus*)	2	2	1	4
Longnose Sucker (*Catostomus catostomus*)	1	3	9	3
Round Whitefish (*Prosopium cylindraceum*)	0	1	1	0
Northern Pike (*Esox lucius*)	0	1	0	1
Burbot (*Lota lota*)	0	0	2	2
Slimy Sculpin (*Cottus cognatus*)	0	0	1	1

Appendix 3: Figures 19 and 20

Appendix 3 contains Figures 19 and 20. They were not included in the body of the thesis because they show the same trend as Figures 17 and 18 (pages 45 and 46), but with added complexity. They are included here to show that the discharge variable was removed but no further insight into CPUE calculations was gained.

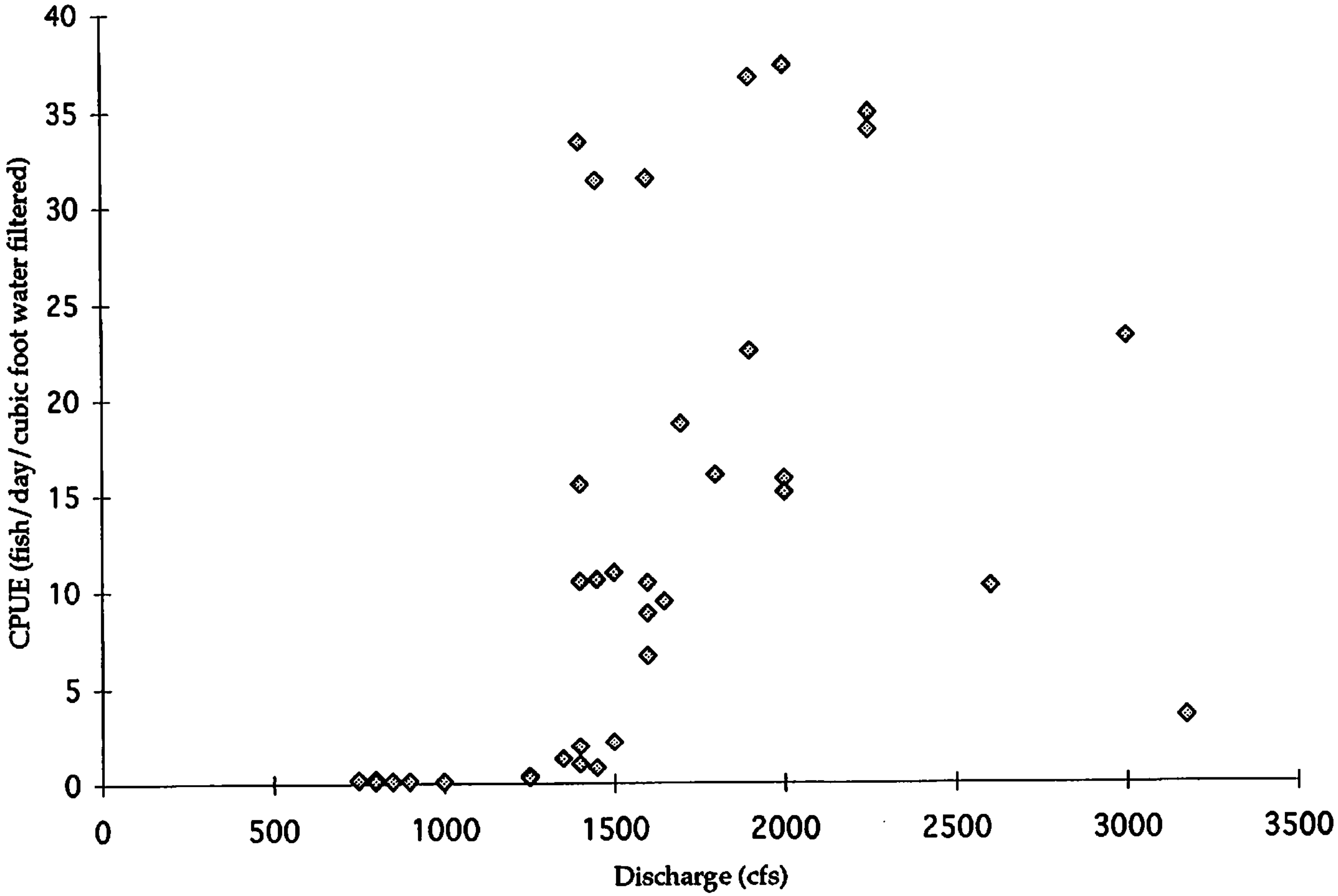


Figure 20. The relationship between CPUE (fish/day/cubic foot of water filtered) and discharge for chinook smolts as measured at the lower site in 1996.

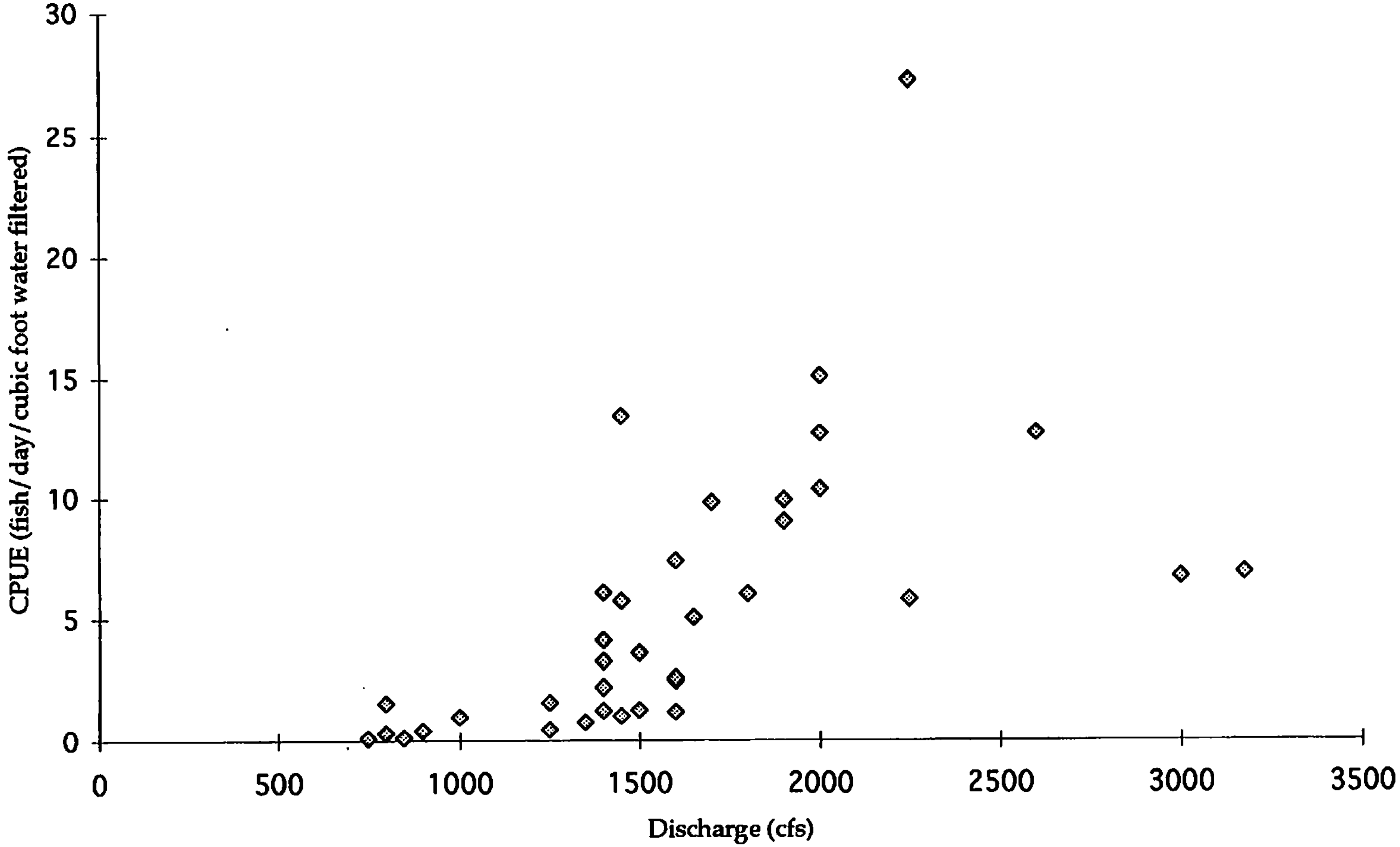


Figure 19. The relationship between CPUE (fish/day/cubic foot of water filtered) and discharge for chum fry as measured at the lower site in 1996.

Appendix 4: Raw Data

Appendix 4 contains the complete set of raw data collected during the 1995 and 1996 field seasons. For each respective year the capture and release data are given first, the water temperature data are given second, and the rotary screw trap revolution rates are given last. Rotary screw traps were used at the upper and lower sites in both field seasons and the inclined plane trap was used at the middle site in 1996. A dipnet and beach seine were used at the upper site in 1995 to increase the number of marked fish in the river and these data are provided as well. In all data sets UC indicates an "Upper Caudal" fin clip and LC indicates a "Lower Caudal" fin clip.

Upper Site Capture Data - Chum, 1995								
Date	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Totals
5/18/95	81	4	6	9	2			102
5/19/95	15	4	9	9	4	2		43
5/20/95	5	0	1	5	4	1		16
5/21/95	8	24	29	27	39	88		215
5/22/95	18	6	12	11	23	12		82
5/23/95	3	1	2	6	2	1		15
5/24/95	3	2	9	2	0	1		17
5/25/95	6	0	3	5	3	0		17
5/26/95	13	2	1	1	0	0		17
5/27/95	25	13	7	7	5	2		59
5/28/95	29	5	5	6	4	2		51
5/29/95	3	0	1	1	0	0		5
5/30/95	4	3	0	0	0	1		8
5/31/95	3	2	0	3	1			9
6/1/95	17	6	2	2	0	0		27
6/2/95	12	2	0	3	0	0		17
6/3/95	10	3	1	1	2	0		17
6/4/95	16	6	2	1	1	4		30
6/5/95	1	2	3	1	1	3		11
6/6/95	4	0	1	1				6
6/7/95	9	2	2	0				13
6/8/95	13	0	1	0				14
6/9/95								0
6/10/95	5	1	1	3				10
6/11/95	1	3	1	3				8
6/12/95	0	1	3	1				5
6/13/95	0	0	2	1				3
6/14/95	0	1	0					1
6/15/95	1	2	0					3
6/16/95	0	0	0					0
6/17/95								0
6/18/95	12	16	13	12	25	12	11	101
6/19/95	7	7	11	7	5	2		39
6/20/95	0	3	3	1	2	5		14
6/21/95	0	0	0	0	0	0		0
6/22/95	0	3	1	0	0	0		4
							Grand Total:	979

Upper Site Capture Data - Chinook								
Date	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Totals
5/18/95	0	0	1	2	0			3
5/19/95	0	0	1	0	0	0		1
5/20/95								0
5/21/95	0	0	0	5	6	3		14
5/22/95	3	0	1	1	1	3		9
5/23/95	0	0	0	1	4	2		7
5/24/95	0	0	0	1	1	0		2
5/25/95	0	0	0	1	1	3		5
5/26/95	0	0	0	0	0	1		1
5/27/95	1	0	0	0	0	0		1
5/28/95	0	0	0	0	0	1		1
5/29/95	0	0	0	0	0	0		0
5/30/95	0	0	0	0	0	0		0
5/31/95	0	0	0	0	0			0
6/1/95	0	0	0	0	0	0		0
6/2/95	0	0	0	0	0	0		0
6/3/95	0	0	0	0	0	0		0
6/4/95	0	0	0	0	0	0		0
6/5/95	0	0	0	0	0	0		0
6/6/95	0	0	0	0				0
6/7/95	0	0	0	0				0
6/8/95	0	0	0	0				0
6/9/95								0
6/10/95	0	0	0	0				0
6/11/95	0	0	0	0				0
6/12/95	0	0	0	0				0
6/13/95	0	0	0	0				0
6/14/95	0	0	0					0
6/15/95	0	0	0					0
6/16/95	0	0	0					0
6/17/95								0
6/18/95	0	0	0	0	0	0	0	0
6/19/95	0	0	0	0	0	0		0
6/20/95	0	0	0	0	0	0		0
6/21/95	4	5	0	3	0	1		13
6/22/95	4	5	9	10	7	3		38
							Grand Total:	95

Upper Site Capture Data - Chum, Dipnetting, 1995					
Date	Session 1	Session 2	Session 3	Session 4	Totals
5/28/95	7				7
5/29/95	78	33	34		145
5/30/95	31	40	5		76
5/31/95	71	42			113
6/1/95					0
6/2/95	10	61	37		108
6/3/95	16	56			72
6/4/95	42	65			107
6/5/95	61	47	49		157
6/6/95	65	37			102
6/7/95	49	21			70
6/8/95	12	39			51
6/9/95					0
6/10/95	33	98	138		269
6/11/95	62	57	70	35	224
6/12/95	11	59	157		227
6/13/95	50	100	117		267
				Grand Total:	1995

Upper Site Capture Data - Chum, Beach Seine, 1995					
Date	Session 1	Session 2	Totals		
6/14/95	100	467	567		
6/15/95	162		162		
6/16/95	106		106		
		Grand Total:	835		

Upper Site Release Data - Chum, 1995							
Date	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Totals
5/18/95	81	10	11				102
5/19/95	15	4	9	7	8		43
5/20/95	5	1	5				11
5/21/95	4	7	24	28	26	39	128
5/22/95	83	7	5	10	11		116
5/23/95	3	3	6				12
5/24/95	3	2	9				14
5/25/95	1	5					6
5/26/95	3	12	2	1	1		19
5/27/95	25	13					38
5/28/95	7	29	5	6			47
5/29/95	6	3	79	31			119
5/30/95	33	4	3	31			71
5/31/95	49	73					122
6/1/95	46	16	2	6			70
6/2/95	1	21	61				83
6/3/95	37	26					63
6/4/95	59	65					124
6/5/95	65	66	50	1			182
6/6/95	70	43					113
6/7/95	61	26					87
6/8/95	30	1	52				83
6/9/95							0
6/10/95	5	34	99	141			279
6/11/95	63	62	70	38			233
6/12/95	12	64	161				237
6/13/95	50	101	119				270
6/14/95	109	480					589
6/15/95	166						166
6/16/95	123						123
6/17/95							0
6/18/95	12	25	12	12	14	13	88
6/19/95	11	7	7	11	7	4	47
6/20/95	2	2	4	1			9
6/21/95							0
6/22/95	3	1	0				4
						Grand Total:	3698

Upper Site Release Data - Chinook, 1995					
Date	Hour 1	Hour 2	Hour 3	Hour 4	Totals
5/18/95	1	2			3
5/19/95	1				1
5/20/95	5	6			11
5/21/95	3	3	1	1	8
5/22/95	1				1
5/23/95	2	1	0		3
5/24/95	1				1
5/25/95	4	0	0		4
5/26/95	1	5			6
5/27/95					0
5/28/95	1	5			6
5/29/95					0
5/30/95					0
5/31/95					0
6/1/95					0
6/2/95					0
6/3/95					0
6/4/95					0
6/5/95					0
6/6/95					0
6/7/95					0
6/8/95					0
6/9/95					0
6/10/95					0
6/11/95					0
6/12/95					0
6/13/95					0
6/14/95					0
6/15/95					0
6/16/95					0
6/17/95					0
6/18/95					0
6/19/95					0
6/20/95					0
6/21/95	4	5	3		12
6/22/95	4	5	9	10	28
				Grand Total:	84

Lower Site Capture Data - Chum, 1995									
Date	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Totals	Number Marked
5/16/95	6	5	28	11				50	0
5/17/95	3	3	12	15	6	6		45	0
5/18/95	28	3	7	14	17	4		73	0
5/19/95	4	7	13	21	10	3		58	0
5/20/95	3	0	17	7	3	0		30	0
5/21/95	47	15	30	22	64	72		250	0
5/22/95	44	12	44	33				133	0
5/23/95	6	7	10	11	10	6		50	0
5/24/95	1	2	7	2	4	0		16	0
5/25/95	0	19	5	2	3	2		31	0
5/26/95	8	3	5	8	1	2		27	0
5/27/95	15	63	63	12	23	8		184	0
5/28/95	8	11	9	17	8	5		58	0
5/29/95	3	0	0	1	0	0		4	0
5/30/95	40	1	1	0	0	0		42	0
5/31/95	3	15	24	14	23	11		90	0
6/1/95	3	22	2	7	4	5		43	0
6/2/95	0	0	2	4	0	2		8	0
6/3/95	0	54	29	10	9	1		103	1
6/4/95	64	93	256	194	89	60		756	1
6/5/95	9	13	33	47	25	11		138	0
6/6/95	5	2	1	3	1	4		16	0
6/7/95	1	0	1	2	8	4		16	0
6/8/95								0	0
6/9/95								0	0
6/10/95	0	0	2	0	0	2	3	7	0
6/11/95	0	0	0	1	1	5	0	7	0
6/12/95	0	0						0	0
6/13/95	0	0	0	0	0	0	4	4	0
6/14/95	1	0	0	1	0	0	0	2	0
6/15/95	0	0	0	0	0	0	0	0	0
6/16/95	0	0	0	0	0	0	1	1	0
6/17/95	0	3	0	0	1	1	1	6	0
6/18/95	0	0	1	0	0	0	0	1	0
6/19/95	0	1	0	1	0	0	0	2	0
6/20/95	0	0	0	0	0	0	0	0	0
6/21/95	0	0	0	0	0	0	0	0	0
6/22/95	0	1	0	0	0			1	0
							Grand Totals:	2252	2

Lower Site Capture Data - Chinook, 1995									
Date	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Totals	Number Marked
5/16/95	0	5	11	15				31	0
5/17/95	0	0	17	17	15	3		52	0
5/18/95	1	0	10	11	5	1		28	0
5/19/95	0	1	2	7	4	1		15	0
5/20/95	0	0	0	4	0	0		4	0
5/21/95	1	1	2	20	8	8		40	0
5/22/95	6	12	14	2				34	0
5/23/95	0	0	7	12	14	0		33	0
5/24/95	0	0	2	8	3	2		15	0
5/25/95	1	3	5	5	0	0		14	0
5/26/95	0	0	0	6	1	0		7	0
5/27/95	0	0	4	10	3	1		18	0
5/28/95	0	0	0	2	1	0		3	0
5/29/95	0	0	0	0	1	0		1	0
5/30/95	0	0	0	1	0	0		1	0
5/31/95	0	0	0	0	0	0		0	0
6/1/95	0	0	0	1	0	0		1	0
6/2/95	0	0	0	0	0	0		0	0
6/3/95	0	0	0	1	0	0		1	0
6/4/95	0	3	6	12	7	0		28	0
6/5/95	0	0	0	0	2	0		2	0
6/6/95	0	0	1	0	0	0		1	0
6/7/95	0	0	0	0	0	0		0	0
6/8/95								0	0
6/9/95								0	0
6/10/95	0	0	0	0	0	0	0	0	0
6/11/95	0	0	0	0	0	0	0	0	0
6/12/95	0	0						0	0
6/13/95	0	0	0	0	0	0	0	0	0
6/14/95	0	0	0	0	0	0	0	0	0
6/15/95	0	0	0	0	0	0	0	0	0
6/16/95	0	0	0	0	0	0	0	0	0
6/17/95	0	0	0	0	0	0	0	0	0
6/18/95	0	0	0	0	0	0	0	0	0
6/19/95	0	0	0	0	0	0	0	0	0
6/20/95	0	0	0	0	0	0	0	0	0
6/21/95	0	0	0	0	0	0	0	0	0
6/22/95	0	0	0	0	0			0	0
							Grand Totals:	329	0

Water Temperature (Fahrenheit) - Lower Site, 1995																								
Date	12:30AM	1:30 AM	2:30 AM	3:30 AM	4:30 AM	5:30 AM	6:30 AM	7:30 AM	8:30 AM	9:30 AM	10:30AM	11:30AM	12:30 PM	1:30 PM	2:30 PM	3:30 PM	4:30 PM	5:30 PM	6:30 PM	7:30 PM	8:30 PM	9:30 PM	10:30 PM	11:30 PM
5/16/95	44		43																		45		44	
5/17/95	44		44	44		42																44		44
5/18/95	44		44	43		43																44		44
5/19/95	46		45	45		45																47		46
5/20/95	44		43	43		42																44		44
5/21/95	43		43	42		43																43		43
5/22/95			43	43		41																44		
5/23/95	46		45	45		44																46		46
5/24/95	46		46	46		46																48		46
5/25/95	48		48	47		47																48		48
5/26/95	47		48	46		46																48		48
5/27/95	49		49	49		48																49		49
5/28/95	49		49	48		48																50		50
5/29/95	47		46	46		45																48		47
5/30/95	47		47	47		45																48		48
5/31/95	48		47	47																	48	48		48
6/1/95	48		48	48																	49	49		48
6/2/95	48		47	47																	49	49		48
6/3/95	50		49	49																	51	51		50
6/4/95	49		49	49																	50	50		50
6/5/95																								
6/6/95																								
6/7/95																								
6/8/95																								
6/9/95																								
6/10/95																								
6/11/95								53	53	53	53	53	54	55										
6/12/95																					56	56		
6/13/95								52	52	53	54	54	54	55										
6/14/95								53	53	54	55	55	56	56										
6/15/95								53	54	53	54	54	54	54										
6/16/95								52	52	52	53	52	52	52										
6/17/95												50	51	51	53	52	53	53						
6/18/95										51	50	53	52	53	53	53								
6/19/95										53	53	55	56	55	56	56								
6/20/95										54	54	55	55	55	56	56								
6/21/95										54	54	55	55	56	56	56								
6/22/95										54	55				57	58				58				

Water Temperature (Fahrenheit) - Upper Site, 1995																								
Date	12:30AM	1:30 AM	2:30 AM	3:30 AM	4:30 AM	5:30 AM	6:30 AM	7:30 AM	8:30 AM	9:30 AM	10:30AM	11:30AM	12:30 PM	1:30 PM	2:30 PM	3:30 PM	4:30 PM	5:30 PM	6:30 PM	7:30 PM	8:30 PM	9:30 PM	10:30 PM	11:30 PM
5/18/95	44		44	44																		44		44
5/19/95		46	46	45																		46	46	46
5/20/95		42	42	42																		43	43	43
5/21/95		42	41	41																		43	42	42
5/22/95		43	41	42																		44	43	43
5/23/95	46		46																			46	46	46
5/24/95	47		46	46																		47	47	47
5/25/95	48		47	47																		48	48	48
5/26/95	47		47	47																		49	48	47
5/27/95	48		48	48																		49	49	49
5/28/95	48	49																		49	50	49	48	
5/29/95																			46	48	48	46	46	46
5/30/95	47																			48	48	48	48	47
5/31/95																				48	48	48	47	47
6/1/95	48																			47	48	48	48	48
6/2/95	47																			47	47	47	47	47
6/3/95																								
6/4/95																								
6/5/95																								
6/6/95																								
6/7/95																								
6/8/95																								
6/9/95																								
6/10/95																								
6/11/95																								
6/12/95																								
6/13/95																								
6/14/95																								
6/15/95																								
6/16/95																								
6/17/95																								
6/18/95	52		52							50	49	50											52	52
6/19/95													53	53	54	54	55	55						
6/20/95									53		53	54	54		55	56								
6/21/95									53	53	53		54		54	55								
6/22/95									54	54	55		56		56	57								

Rotary Screw Trap Revolutions - Upper Site, 1995							
Date	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7
5/18/95	3.25	3	3.25	3.25	3.25		
5/19/95	3	3	2.75	2.75	2.75	3	
5/20/95	2.75	2.75	3	3.25	3	3.25	
5/21/95	3.25	3.75	3.5	3	2.5	3.5	
5/22/95	2.5	3.5	2.75	3.25	2.75		
5/23/95	3	3	3	3.25	3	3.5	
5/24/95	4	3.5	3.5	3	3.5	3	
5/25/95	1.75	1.75	2	2.5	2.25	2.25	
5/26/95	2.25	2.5	2.75	3	2.75	3	
5/27/95	3	3.75	3.75	3.5	3.5	3.5	
5/28/95	3.5	3.5	3.5	3.5	3	3.5	
5/29/95	3.25	3	3	3	3.25	3	
5/30/95	2.5	2.5	2.5	2.5	2.5	2.75	
5/31/95	3.25	2.75	2.75	2.75	3		
6/1/95	3.75	3.75	4	3.75	3.75	3.75	
6/2/95	3.25	3.75	3.5	3.75	3.75	3.5	
6/3/95	3.75	4	4	3.75	3.75	3.75	
6/4/95	4	4	4.5	4	4	4	
6/5/95	4.75	4.75	4.25	4.5	4.75	4.5	
6/6/95	4.5	4.5	4.25	4.5			
6/7/95	3.75	4	3.75	3.75			
6/8/95	3.75	4	3.75	3.75			
6/9/95							
6/10/95	3.5	3.5	3.5	3.75			
6/11/95	3.25	3.25	3	3.25			
6/12/95	3.25	3.25	3	3			
6/13/95	3.25	3	3	2.75			
6/14/95	2.5	2.75	2.75				
6/15/95	2.5	2.75	2.75				
6/16/95	2.5	2.25	2.5				
6/17/95							
6/18/95	4.75	5.25	5	4.75	5	5	5
6/19/95	4.75	4.75	4.75	4.75	4.75	4.75	
6/20/95	4.75	4.25	4.5	4.5	4.75	4.75	
6/21/95	4.5	4.5	4.5	4.5	4.5	4.25	
6/22/95	4.5	4.5	4.5	4.5	4.5	4.25	

Rotary Screw Trap Revolutions - Lower Site, 1995							
Date	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7
5/16/95	8	7.75	7.5	7.5			
5/17/95	7	6.25	6.75	7	6.5	6.25	
5/18/95	6.5	6.25	6.5	6.5	6.25	6.5	
5/19/95	6.25	6.25	5.75	6	6	6.25	
5/20/95	6	5.5	5	5.25	5.5	5.25	
5/21/95	5.5	6.25	6.5	6.75	6.25	6.75	
5/22/95	6.75	6.5	6.75	6.25			
5/23/95	6.75	6.5	6.75	6.5	6.25	6.5	
5/24/95	5.5	6	5.5	5.25	4.75	5	
5/25/95	6.5	6.5	6.75	7	7	6.75	
5/26/95	6.5	6.75	6.5	6.75	6.75	6.5	
5/27/95	7.5	7	7.75	7.25	7.25	7	
5/28/95	6.75	7.25	7	7	7	6.5	
5/29/95	5.75	6.25	6.25	6	6.25	6.5	
5/30/95	6.25	6	6.25	6.75	6.75	6.5	
5/31/95	7	7.25	7.25	7	7.25	7	
6/1/95	6.5	6.5	6.25	6.5	6.5	6.25	
6/2/95	6	6.5	6.5	6.25	6.25	6.25	
6/3/95	6.5	5.75	6.5	7	6.75	6.75	
6/4/95	7.75	8	7.75	8	7.5	8	
6/5/95	7.25	7.75	7.75	7.5	7.5	7	
6/6/95	6.75	7.25	7	7.25	6.75	7	
6/7/95	6.5	6.5	6	6.25	6.25	6.75	
6/8/95							
6/9/95							
6/10/95	5	5.5	5.5	5.25	5.25	5.5	5.25
6/11/95	5	5.5	5.25	5.25	5.25	5	5.25
6/12/95	5.25	5					
6/13/95	5	5.25	5.25	5	5.25	5.25	5
6/14/95	4.75	4.75	5	5	5	5	4.75
6/15/95	4.25	4.25	4.25	4	4.25	4.25	4
6/16/95	4.75	4.25	4	4.25	4.25	4.5	4.5
6/17/95	4.75	4.5	4.25	4.5	4.75	4.25	4.75
6/18/95	4	4.5	4.5	4.25	4.75	5.25	5.5
6/19/95	5.5	5.75	5	5	4.75	4.75	5
6/20/95	5	5	5	5	5	5	4.75
6/21/95	4.5	4.75	4.75	4.5	4.5	4.5	4.75
6/22/95	4.75	4.75	4.75	4.5	4.5		

Upper Site Capture Data - Chum, 1996											
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Totals	Number Marked
5/6/96	16									16	15
5/7/96	19	41	48	31	43					182	179
5/8/96	12	6	6	20	22	33				99	99
5/9/96										0	0
5/10/96	8	5	4	6	6	11	13	17		70	68
5/11/96	12	12	12	4	12	6	21	39		118	117
5/12/96	29	14	5	11	19	19	24			121	119
5/13/96	13	21	9	16	18	30	17			124	124
5/14/96	6	8	13	7	9	14	10			67	67
5/15/96	7	8	10	4						29	29
5/16/96	4	1	2	1	2	6	14			30	30
5/17/96	19	22	8	3	2	1	3			58	57
5/18/96	6	1	0	2	0	0	0	0		9	9
5/19/96	0	0	1	1	0	2	5	2		11	11
5/20/96	7	5								12	12
5/21/96	11	1	2	1	0	1	4	1		21	21
5/22/96	1	1	1	3	3	1	1	0		11	11
5/23/96	8	6								14	14
5/24/96	9	13	8							30	30
5/25/96	3	13								16	16
5/26/96	0	1	5							6	6
5/27/96	7	4	4							15	15
5/28/96	3	4	8							15	15
5/29/96	5	1	5							11	11
5/30/96	8	7	5							20	20
5/31/96	13	7	5							25	25
6/1/96	7	5	3							15	15
6/2/96	6	2	2							10	10
6/3/96	2	2	1							5	5
6/4/96	3	3	2							8	8
6/5/96	2	2	1							5	5
6/6/96	1	0	1							2	2
6/7/96	0	2	0							2	2
6/8/96	2	0	0							2	2
6/9/96	0									0	0
6/10/96	3									3	3
									Grand Totals:	1182	1172

Upper Site Capture Data - Chinook, 1996											
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Totals	Number Marked
5/7/96	27	57	50	57	36					227	226
5/8/96	19	26	25	25	37	22				154	154
5/9/96										0	0
5/10/96	4	8	12	24	21	13	8	12		102	102
5/11/96	8	9	28	28	24	17	24	18		156	154
5/12/96	31	23	22	37	41	33	26			213	209
5/13/96	25	16	7	23	20	11	6			108	107
5/14/96	2	3	7	3	8	3	3			29	29
5/15/96	10	15	17	26						68	68
5/16/96	20	23	17	4	13	13	10			100	100
5/17/96	23	20	30	21	11	3	6			114	113
5/18/96	5	2	5	7	11	1	8	8		47	47
5/19/96	4	3	2	9	14	4	5	8		49	49
5/20/96	33	17								50	48
5/21/96	3	1	5	3	9	9	7	7	9	53	53
5/22/96	3	2	6	14	24	13	4	22		88	88
5/23/96	20	27								47	47
5/24/96	44	69	73							186	139
5/25/96	28	29								57	57
5/26/96	8	14	10							32	32
5/27/96	11	35	39							85	85
5/28/96	22	15	15							52	52
5/29/96	7	11	2							20	20
5/30/96	5	4	6							15	15
5/31/96	3	4	3							10	10
6/1/96	7	13	5							25	25
6/2/96	2	6	4							12	12
6/3/96	1	10	7							18	18
6/4/96	12	8	3							23	23
6/5/96	0	2	1							3	3
6/6/96	1	2	0							3	3
6/7/96	1	2	0							3	3
6/8/96	0	1	1							2	2
6/9/96	1									1	1
6/10/96	3									3	3
									Grand Totals:	2155	2097

Middle Site Unmarked Cap./Rel. Data - Chum, 1996

Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Totals	Number LC Rel.
5/8/96	0	1	3	0							4	4
5/9/96	10	7	11	1	1	0	1	0			31	31
5/10/96	12	3	1	0	0	0	0	0			16	16
5/11/96	6	1	0	4	0	0	0	6			17	17
5/12/96	1	3	2	0	2	1	1	4	19		33	33
5/13/96	0	0	3	8	2	3	3	7			26	26
5/14/96	5	0	1	0	0	0	1				7	7
5/15/96	1	0	2	1	2	1	0	1	1		9	9
5/16/96	2	4	2	0	2	0	0	1	0		11	11
5/17/96	1	3	9	1	11	5	1	1	0		32	32
5/18/96	4	0	2	0	0	0	0	1	1		8	8
5/19/96	3	3	0	0	0	0	4	1	0	1	12	12
5/20/96	2	0	1	1	0	1	0	1	0	0	6	5
5/21/96	1	0	0	1	0	0	0	1	0		3	3
5/22/96	0	0	0	0	0	0	0	0	0	0	0	0
5/23/96	2	3	2	1	2	0	0	2	0	0	12	12
5/24/96	4	2	2								8	8
5/25/96	3	0	1	0	0	2	0	1	0	3	10	10
5/26/96	0	0	1								1	1
5/27/96	3	2	0								5	5
5/28/96	0	2	0								2	2
5/29/96	2	11	1								14	14
5/30/96	0	0	2	16	10	0	1	0	0	0	29	29
5/31/96	1	0	1	1	2	1					6	6
6/1/96	0	2	1								3	3
6/2/96	0	0	1								1	1
6/3/96	1	0	0								1	1
6/4/96	1	1	1								3	3
6/5/96	3	0	0								3	3
6/6/96	1	0	0								1	1
6/7/96	0	0	1								1	1
6/8/96	0	0	0								0	0
6/9/96	1										1	1
6/10/96	3										3	3
6/11/96	11										11	11
										Grand Totals:	330	329

Middle Site Marked Cap./Rel. Data - Chum, 1996												
												Number UC/LC
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Totals	Released
5/8/96	0	0	0	0							0	0
5/9/96	0	0	0	0	0	0	0	0			0	0
5/10/96	0	0	0	0	0	0	0	0			0	0
5/11/96	0	0	0	0	0	0	0	0			0	0
5/12/96	0	0	0	0	0	0	0	0	0		0	0
5/13/96	0	0	0	0	0	0	0	0			0	0
5/14/96	0	0	0	0	0	0	0				0	0
5/15/96	0	0	0	0	0	0	0	0	0		0	0
5/16/96	0	0	0	0	0	0	0	0	0		0	0
5/17/96	0	0	0	0	0	0	0	0	0		0	0
5/18/96	0	0	0	0	0	0	0	0	0		0	0
5/19/96	0	0	0	0	0	0	0	0	0	0	0	0
5/20/96	0	0	0	0	0	0	0	0	0	0	0	0
5/21/96	0	0	0	0	0	0	0	0	0		0	0
5/22/96	0	0	0	0	0	0	0	0	0	0	0	0
5/23/96	0	0	0	0	0	0	0	0	0	0	0	0
5/24/96	0	0	0								0	0
5/25/96	0	0	0	0	0	0	0	0	0	0	0	0
5/26/96	0	0	0								0	0
5/27/96	0	0	0								0	0
5/28/96	0	0	0								0	0
5/29/96	0	0	0								0	0
5/30/96	0	0	0	0	0	0	0	0	0	0	0	0
5/31/96	0	0	0	0	0	0					0	0
6/1/96	0	0	0								0	0
6/2/96	0	0	0								0	0
6/3/96	0	0	0								0	0
6/4/96	0	0	0								0	0
6/5/96	0	0	0								0	0
6/6/96	0	0	0								0	0
6/7/96	0	0	0								0	0
6/8/96	0	0	0								0	0
6/9/96	0										0	0
6/10/96	0										0	0
6/11/96	0										0	0
										Grand Totals:	0	0

Middle Site Unmarked Cap./Rel. Data - Chinook			1996									
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Totals	Number LC Rel.
5/8/96	9	19	15	24							67	67
5/9/96	7	11	11	25	22	19	19	16			130	130
5/10/96	8	8	9	14	53	16	15	11			134	134
5/11/96	5	3	6	47	24	12	13	15			125	125
5/12/96	4	9	9	8	12	16	22	15	17		112	112
5/13/96	5	8	4	14	11	18	10	16			86	86
5/14/96	7	1	1	2	2	4	2				19	19
5/15/96	3	2	5	7	17	19	11	2	12		78	78
5/16/96	8	3	7	7	6	8	8	5	15		67	67
5/17/96	1	1	3	17	17	15	10	5	2		71	71
5/18/96	0	1	2	5	2	7	4	2	8		31	31
5/19/96	0	2	1	3	3	9	7	3	9	3	40	40
5/20/96	2	7	4	0	3	5	10	5	9	2	47	47
5/21/96	1	5	0	1	7	6	8	5	6		39	39
5/22/96	5	2	3	5	1	9	7	5	9	1	47	47
5/23/96	0	1	1	2	36	12	8	8	2	24	94	94
5/24/96	1	11	64								76	76
5/25/96	4	4	6	11	0	5	13	23	10	8	84	84
5/26/96	8	7	9								24	24
5/27/96	4	1	15								20	20
5/28/96	2	1	11								14	14
5/29/96	2	2	11								15	15
5/30/96	0	0	0	0	2	2	2	2	0	2	10	10
5/31/96	0	1	0	0	2	2					5	5
6/1/96	1	1	10								12	12
6/2/96	0	4	6								10	10
6/3/96	0	2	5								7	7
6/4/96	1	0	1								2	2
6/5/96	1	3	5								9	9
6/6/96	1	0	3								4	4
6/7/96	0	1	2								3	3
6/8/96	0	0	1								1	1
6/9/96	3										3	3
6/10/96	3										3	3
6/11/96	3										3	3
										Grand Totals:	1492	1492

Middle Site Marked Cap./Rel. Data - Chinook, 1996												
												Number UC/LC
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Totals	Released
5/8/96	0	0	0	0							0	0
5/9/96	0	0	0	0	0	0	1	0			1	1
5/10/96	0	0	0	0	0	0	0	0			0	0
5/11/96	0	0	0	0	0	0	0	1			1	1
5/12/96	0	0	1	0	0	0	0	0	0		1	1
5/13/96	0	0	0	0	0	0	0	0			0	0
5/14/96	0	0	0	0	0	1	0				1	1
5/15/96	0	0	0	0	1	0	0	0	0		1	1
5/16/96	0	0	0	0	0	0	0	0	1		1	1
5/17/96	0	0	0	0	0	0	1	0	0		1	1
5/18/96	0	0	0	0	0	0	0	0	0		0	0
5/19/96	0	0	0	0	0	0	1	0	0	0	1	1
5/20/96	0	2	0	0	0	0	1	1	1	0	5	5
5/21/96	0	0	0	0	0	1	0	0	0		1	1
5/22/96	0	0	0	0	0	0	1	0	0	0	1	1
5/23/96	0	0	0	0	3	0	0	0	0	0	3	3
5/24/96	0	0	0								0	0
5/25/96	0	0	0	0	0	0	0	0	0	0	0	0
5/26/96	0	0	0								0	0
5/27/96	1	0	1								2	2
5/28/96	0	0	1								1	1
5/29/96	0	0	0								0	0
5/30/96	0	0	0	0	0	0	0	0	0	0	0	0
5/31/96	0	0	0	0	0	0					0	0
6/1/96	0	0	0								0	0
6/2/96	0	0	0								0	0
6/3/96	0	0	1								1	1
6/4/96	0	0	0								0	0
6/5/96	0	0	0								0	0
6/6/96	0	0	0								0	0
6/7/96	0	0	0								0	0
6/8/96	0	0	0								0	0
6/9/96	0										0	0
6/10/96	0										0	0
6/11/96	0										0	0
										Grand Totals:	22	22

Lower Site Unmarked Capture Data - Chum, 1996

Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	63	80	36									179
5/7/96	42	58	17	32								149
5/8/96	144	27	11	7	54							243
5/9/96	105	66	8	21								200
5/10/96	24	50	32	12	19							137
5/11/96	38	47	21	8	17	28						159
5/12/96	92	80	74	12	60	117						435
5/13/96	25	14	32	31	3	22	25	41				193
5/14/96	6	24	38	10	3	3	11	14				109
5/15/96	8	12	12	9	5	6	14	17	15			98
5/16/96	17	2	7	4	7	7	8	21	16			89
5/17/96	12	26	27	35	23	13	1	17				154
5/18/96	15	5	16	7	4	3	10	20	8			88
5/19/96	12	4	37	3	2	2	5	6				71
5/20/96	3	6	9									18
5/21/96	6	6	3	3	5	4	3	6	5	2	2	45
5/22/96	5	6	7									18
5/23/96	1	5	9	9	12	35	3	11	4			89
5/24/96	28	32	27									87
5/25/96	59	23	31									113
5/26/96	25	9	6									40
5/27/96	3	11	5									19
5/28/96	1	2	1	6	2	6	6	5	4	7		40
5/29/96	3	1	5	13	13	18						53
5/30/96	3	1	1	5	0	0	2	2	0			14
5/31/96	8	4	18									30
6/1/96	22	13	23									58
6/2/96	3	2	4									9
6/3/96	1	3	2									6
6/4/96	4	6	12									22
6/5/96	6	4	3									13
6/6/96	3	0	1									4
6/7/96	0	0	1									1
6/8/96	0	2	0									2
6/9/96	0	9	1	4	0	0	0	2				16
6/10/96	1											1
											Grand Total:	3002

Lower Site UC-Clip Capture Data - Chum, 1996												
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	0	0	0									0
5/7/96	0	0	0	0								0
5/8/96	0	0	0	0	0							0
5/9/96	0	0	0	0								0
5/10/96	0	1	0	0	0							1
5/11/96	0	0	0	0	0	0						0
5/12/96	0	0	0	0	0	0						0
5/13/96	0	0	0	0	0	0	0	0				0
5/14/96	0	0	0	0	0	0	0	0				0
5/15/96	0	0	0	0	0	0	0	0	0			0
5/16/96	0	0	0	0	0	0	0	0	0			0
5/17/96	0	0	0	0	0	0	0	0				0
5/18/96	0	0	0	0	0	0	0	0	0			0
5/19/96	0	0	0	0	0	0	0	0				0
5/20/96	0	0	0									0
5/21/96	0	0	0	0	0	0	0	0	0	0	0	0
5/22/96	0	0	0									0
5/23/96	0	0	0	0	0	0	0	0	0			0
5/24/96	2	0	0									2
5/25/96	0	0	0									0
5/26/96	0	0	0									0
5/27/96	0	0	0									0
5/28/96	0	0	0	0	0	0	0	0	0	0		0
5/29/96	0	0	0	0	0	1						1
5/30/96	0	0	0	0	0	0	0	0	0			0
5/31/96	1	0	0									1
6/1/96	2	0	0									2
6/2/96	0	0	1									1
6/3/96	0	0	0									0
6/4/96	0	0	0									0
6/5/96	0	0	0									0
6/6/96	0	0	0									0
6/7/96	0	0	0									0
6/8/96	0	1	0									1
6/9/96	0	0	0	0	0	0	0	0				0
6/10/96	0											0
											Grand Total:	9

Lower Site LC-Clip Capture Data - Chum, 1996												
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	0	0	0									0
5/7/96	0	0	0	0								0
5/8/96	0	0	0	0	0							0
5/9/96	0	0	0	0								0
5/10/96	0	0	0	0	0							0
5/11/96	0	0	0	0	0	0						0
5/12/96	0	0	0	0	0	0						0
5/13/96	0	0	0	0	0	0	0	0				0
5/14/96	0	0	0	0	0	0	0	0				0
5/15/96	0	0	0	0	0	0	0	0	0			0
5/16/96	0	0	0	0	0	0	0	0	0			0
5/17/96	0	0	0	0	0	0	0	0				0
5/18/96	0	0	0	0	0	0	0	0	0			0
5/19/96	0	0	0	0	0	0	0	0				0
5/20/96	0	0	0									0
5/21/96	0	0	0	0	0	0	0	0	0	0	0	0
5/22/96	0	0	0									0
5/23/96	0	0	1	0	0	0	0	0	0			1
5/24/96	0	0	1									1
5/25/96	0	0	0									0
5/26/96	0	0	0									0
5/27/96	0	0	0									0
5/28/96	0	0	0	0	0	0	0	0	0	0		0
5/29/96	0	0	0	0	0	1						1
5/30/96	0	0	0	0	0	0	0	0	0			0
5/31/96	0	0	0									0
6/1/96	0	0	0									0
6/2/96	0	0	0									0
6/3/96	0	0	0									0
6/4/96	0	0	0									0
6/5/96	0	0	0									0
6/6/96	0	0	0									0
6/7/96	0	0	0									0
6/8/96	0	0	0									0
6/9/96	0	0	0	0	0	0	0	0				0
6/10/96	0											0
											Grand Total:	3

Lower Site UC/LC-Clip Capture Data - Chum, 1996												
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	0	0	0									0
5/7/96	0	0	0	0								0
5/8/96	0	0	0	0	0							0
5/9/96	0	0	0	0								0
5/10/96	0	0	0	0	0							0
5/11/96	0	0	0	0	0	0						0
5/12/96	0	0	0	0	0	0						0
5/13/96	0	0	0	0	0	0	0	0				0
5/14/96	0	0	0	0	0	0	0	0				0
5/15/96	0	0	0	0	0	0	0	0	0			0
5/16/96	0	0	0	0	0	0	0	0	0			0
5/17/96	0	0	0	0	0	0	0	0				0
5/18/96	0	0	0	0	0	0	0	0	0			0
5/19/96	0	0	0	0	0	0	0	0				0
5/20/96	0	0	0									0
5/21/96	0	0	0	0	0	0	0	0	0	0	0	0
5/22/96	0	0	0									0
5/23/96	0	0	0	0	0	0	0	0	0			0
5/24/96	0	0	0									0
5/25/96	0	0	0									0
5/26/96	0	0	0									0
5/27/96	0	0	0									0
5/28/96	0	0	0	0	0	0	0	0	0	0		0
5/29/96	0	0	0	0	0	0						0
5/30/96	0	0	0	0	0	0	0	0	0			0
5/31/96	0	0	0									0
6/1/96	0	0	0									0
6/2/96	0	0	0									0
6/3/96	0	0	0									0
6/4/96	0	0	0									0
6/5/96	0	0	0									0
6/6/96	0	0	0									0
6/7/96	0	0	0									0
6/8/96	0	0	0									0
6/9/96	0	0	0	0	0	0	0	0				0
6/10/96	0											0
											Grand Total:	0

Lower Site Unmarked Capture Data - Chinook, 1996												
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	22	41	78									141
5/7/96	50	67	104	64								285
5/8/96	28	89	38	33	64							252
5/9/96	24	115	45	47								231
5/10/96	41	63	100	57	76							337
5/11/96	28	82	97	100	110	164						581
5/12/96	123	175	84	47	42	71						542
5/13/96	39	40	15	20	5	9	8	18				154
5/14/96	9	7	3	3	16	2	5	11				56
5/15/96	31	37	47	71	42	23	20	32	32			335
5/16/96	38	52	79	91	88	75	48	21	37			529
5/17/96	13	47	68	165	127	45	39	43				547
5/18/96	11	16	17	25	38	44	43	22	8			224
5/19/96	12	4	11	19	21	9	31	19				126
5/20/96	28	44	72									144
5/21/96	7	12	7	12	25	58	30	19	10	12	12	204
5/22/96	17	78	50									145
5/23/96	8	24	105	70	169	53	26	5	14			474
5/24/96	63	134	291									488
5/25/96	127	206	145									478
5/26/96	44	72	46									162
5/27/96	12	27	97									136
5/28/96	5	1	3	16	5	20	15	20	11	4		100
5/29/96	3	2	0	4	11	12						32
5/30/96	0	0	0	0	2	0	5	1	2			10
5/31/96	2	2	10									14
6/1/96	6	9	12									27
6/2/96	3	7	6									16
6/3/96	0	2	3									5
6/4/96	1	1	1									3
6/5/96	0	1	0									1
6/6/96	1	0	0									1
6/7/96	0	0	1									1
6/8/96	0	0	2									2
6/9/96	0	1	0	0	0	0	0	0				1
6/10/96	2											2
											Grand Total:	6786

Lower Site UC-Clip Capture Data - Chinook, 1996												
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	0	0	0									0
5/7/96	0	0	0	0								0
5/8/96	0	0	0	1	0							1
5/9/96	0	0	0	1								1
5/10/96	0	0	0	1	1							2
5/11/96	0	2	0	0	0	3						5
5/12/96	1	0	0	0	1	0						2
5/13/96	0	1	0	0	0	0	0	0				1
5/14/96	0	0	0	0	0	0	0	0				0
5/15/96	0	0	0	3	1	0	0	0	0			4
5/16/96	0	1	0	0	0	0	0	0	0			1
5/17/96	0	0	2	0	1	0	0	0				3
5/18/96	0	0	1	0	1	1	1	1	0			5
5/19/96	1	0	1	0	0	0	2	0				4
5/20/96	0	1	1									2
5/21/96	0	1	1	0	0	1	0	1	0	0	0	4
5/22/96	0	1	1									2
5/23/96	1	0	1	3	3	0	0	0	0			8
5/24/96	0	4	0									4
5/25/96	0	1	3									4
5/26/96	1	1	1									3
5/27/96	2	0	1									3
5/28/96	0	0	0	1	0	0	0	0	1	0		2
5/29/96	0	0	0	0	0	0						0
5/30/96	0	0	0	0	0	0	0	0	1			1
5/31/96	0	0	0									0
6/1/96	0	0	1									1
6/2/96	1	0	0									1
6/3/96	0	0	0									0
6/4/96	0	0	0									0
6/5/96	0	0	0									0
6/6/96	0	0	0									0
6/7/96	0	0	0									0
6/8/96	0	0	0									0
6/9/96	0	0	0	0	0	0	0	0				0
6/10/96	0											0
											Grand Total:	64

Lower Site LC-Clip Capture Data - Chinook, 1996												
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	0	0	0									0
5/7/96	0	0	0	0								0
5/8/96	0	0	0	1	1							2
5/9/96	0	0	5	1								6
5/10/96	2	0	0	0	4							6
5/11/96	0	1	0	0	0	2						3
5/12/96	0	0	0	0	0	0						0
5/13/96	0	0	0	0	0	0	0	0				0
5/14/96	0	0	0	0	0	0	0	0				0
5/15/96	0	0	0	0	0	0	0	0	0			0
5/16/96	0	1	0	2	2	1	0	2	1			9
5/17/96	1	1	0	0	1	3	0	0				6
5/18/96	0	0	0	0	4	1	0	1	0			6
5/19/96	0	0	1	0	0	0	0	2				3
5/20/96	0	4	2									6
5/21/96	1	0	0	0	1	2	0	0	0	1	0	5
5/22/96	0	2	1									3
5/23/96	0	0	3	0	10	2	0	0	0			15
5/24/96	1	0	1									2
5/25/96	0	0	0									0
5/26/96	2	0	0									2
5/27/96	0	0	0									0
5/28/96	0	0	0	0	0	0	0	0	0	0		0
5/29/96	0	0	0	0	2	0						2
5/30/96	0	0	0	0	0	0	0	0	0			0
5/31/96	0	0	0									0
6/1/96	0	0	1									1
6/2/96	0	0	0									0
6/3/96	0	0	0									0
6/4/96	1	0	0									1
6/5/96	0	0	0									0
6/6/96	0	0	0									0
6/7/96	0	0	0									0
6/8/96	0	0	0									0
6/9/96	0	0	0	0	0	0	0	0				0
6/10/96	0											0
											Grand Total:	78

Lower Site UC/LC-Clip Capture Data - Chinook,			1996									
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11	Totals
5/6/96	0	0	0									0
5/7/96	0	0	0	0								0
5/8/96	0	0	0	0	0							0
5/9/96	0	0	0	0								0
5/10/96	0	0	0	0	0							0
5/11/96	0	0	0	0	0	0						0
5/12/96	0	0	0	0	0	0						0
5/13/96	0	0	0	0	0	0	0	0				0
5/14/96	0	0	0	0	0	0	0	0				0
5/15/96	0	0	0	0	0	0	0	0	0			0
5/16/96	0	0	0	0	0	0	0	0	0			0
5/17/96	0	0	0	0	0	0	0	0				0
5/18/96	0	0	0	0	0	0	0	0	0			0
5/19/96	0	0	0	0	0	0	0	0				0
5/20/96	0	0	0									0
5/21/96	0	0	0	0	0	0	0	0	0	0	1	1
5/22/96	0	0	0									0
5/23/96	0	0	0	1	0	0	0	0	0			1
5/24/96	0	0	0									0
5/25/96	0	0	0									0
5/26/96	0	0	0									0
5/27/96	0	0	0									0
5/28/96	0	0	0	0	0	0	0	0	0	0		0
5/29/96	0	0	0	0	0	0						0
5/30/96	0	0	0	0	0	0	0	0	0			0
5/31/96	0	0	0									0
6/1/96	0	0	0									0
6/2/96	0	0	0									0
6/3/96	0	0	0									0
6/4/96	0	0	0									0
6/5/96	0	0	0									0
6/6/96	0	0	0									0
6/7/96	0	0	0									0
6/8/96	0	0	0									0
6/9/96	0	0	0	0	0	0	0	0				0
6/10/96	0											0
											Grand Total:	2

Water Temperature (Celsius) - Upper Site	1996																							
Date	1930	2030	2130	2230	2330	0030	0130	0230	0330	0430	0530	0630	0730	0830	0930	1030	1130	1230	1330	1430	1530	1630	1730	1830
5/6/96			4																					
5/7/96		4.5	4.5			4	4		4															
5/8/96			5		4	4	4	4		4														
5/9/96																								
5/10/96		5.5	5.5	5.5	5	5	5		5	5														
5/11/96		6	6	6		6	6	6	6	6														
5/12/96			6	6	6	6	6	6		6														
5/13/96		6		6	6		6	6*	6*	6*														
5/14/96			5	5	4	4	4	4	4*															
5/15/96	5	5		5	5																			
5/16/96				5	5	5		5	5	5	5													
5/17/96			6	6	6	6	5	5	5															
5/18/96	6	6	6	6		6	6	5	5															
5/19/96		6	6	6	6	6	6	6	6															
5/20/96				7				6																
5/21/96	7	7	7	7	7	7	7	7	7															
5/22/96	8	8	8	8		8	8	8	7															
5/23/96		9			9																			
5/24/96			9			9			8															
5/25/96				9			9																	
5/26/96				9			9			8														
5/27/96			8			7			7															
5/28/96			8			8			7															
5/29/96			9			9			8															
5/30/96			9			9			8															
5/31/96			9			9			9															
6/1/96			10			10			10															
6/2/96			10			9			9															
6/3/96			9			9			9															
6/4/96			9			9			9															
6/5/96			10			10*			10*															
6/6/96			10			10			10															
6/7/96			11			11			11															
6/8/96			10			10			10															
6/9/96														10										
6/10/96														9										

*No temperature data recorded. Average from previous sessions reported.

Water Temperature (Celsius) - Middle Site,1996																								
Date	1830	1930	2030	2130	2230	2330	0030	0130	0230	0330	0430	0530	0630	0730	0830	0930	1030	1130	1230	1330	1430	1530	1630	1730
5/8/96				3		3	3	3																
5/9/96	3	3		3	3	3	3	3	3															
5/10/96		4	4	4	4	4	4		3	3														
5/11/96		6		5	5	5	5	5	5	5														
5/12/96	6	6	6		5	5	5	5	5	5														
5/13/96		5	5	5	5	4	4		4	4														
5/14/96		4	4		3	3	3		3	3														
5/15/96	4	4	4	4	4	4		4	4	4														
5/16/96	4	4	4	4	4	4	4		4	4														
5/17/96	5	5	4.5	4.5	4.5		4	4	4	4														
5/18/96	5	5	5	5	4		3.5	3	3	3														
5/19/96	5	5	5	5	5	5		5	5	4	4													
5/20/96	5.5	5.5	5	5	5	5	5		5	5	4													
5/21/96		6	6	6	6	5	5	5	5	5														
5/22/96	7	6	7	6	6	6	6		6	6	5													
5/23/96	7	7	8	8	7		7	7	7	6	6													
5/24/96		9			8			8																
5/25/96	8	8	8	8		7		7	7	7	6													
5/26/96		8			7			7																
5/27/96		7			7			7																
5/28/96		6.5			6			6																
5/29/96		9			8			7																
5/30/96	8		8	8	8	8	8	8	8	8	8				8				9				10	
5/31/96		8			8			8																
6/1/96		10			10			10																
6/2/96		8			8			7																
6/3/96		8			8			8																
6/4/96		8			8			8																
6/5/96		8			8			8																
6/6/96		9			9			9																
6/7/96		9			9			9																
6/8/96		9			9			9																
6/9/96																9								
6/10/96																9								
6/11/96																8								
6/12/96				8	8	8	8																	

Water Temperature (Celsius) - Lower Site, 1996																								
Date	1930	2030	2130	2230	2330	0030	0130	0230	0330	0430	0530	0630	0730	0830	0930	1030	1130	1230	1330	1430	1530	1630	1730	1830
5/6/96	2	1			1																			
5/7/96	3		3		2.5			0																
5/8/96	3			3			2	2		2														
5/9/96	1			1			0		0															
5/10/96	4	4			4		3		3															
5/11/96	5		5	4		3		4		4														
5/12/96	6		5			5	4		4	4														
5/13/96	4.5	4.5		4.5	4		4	4	4	4														
5/14/96	2	3		3	2.5	2.5	2		2	2														
5/15/96	4	4	4	4		3	3	3.5		3.5	3.5													
5/16/96	4	4	4		4	4	4	4	3	3														
5/17/96	4	4		4	4	4	4	4	4															
5/18/96	4	4	4	4		4	4	3	3	3														
5/19/96	4	4	4	4	4	4	4		4															
5/20/96			5		5			5																
5/21/96	5	5	5	5	5	5	5	5	5	5	5												5	
5/22/96			6		6			6																
5/23/96	7	7		7		7		7		7				7				7				8		
5/24/96		8			7			7																
5/25/96		7			7			7																
5/26/96		8			8			8																
5/27/96		7			6			6																
5/28/96	7	7	6	6	6	6	6	6	6	6				6.5				7				8		
5/29/96		8			8			8																
5/30/96	8	8	8	8	8	8	8	7	6.5															
5/31/96		8			8			8																
6/1/96		8			9			9																
6/2/96		7			8			8																
6/3/96		9			9			8																
6/4/96		9			9			8																
6/5/96		8			8			7																
6/6/96		9			8			8																
6/7/96		10			10			9																
6/8/96		10			10			9																
6/9/96	11	11	10	10	10	10	10	10																
6/10/96															7									

Rotary Screw Trap Revolutions - Upper Site, 1996									
Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9
5/6/96	6.75								
5/7/96	6.75	4.75	4.5	4.75	4.25				
5/8/96	5	4.75	5.25	4.75	5	5			
5/9/96									
5/10/96	5.5	5.5	5.5	5.25	5.25	5	5.25	5.25	
5/11/96	7	6.75	6.75	6.75	6.75	6.5	7.25	7	
5/12/96	7.5	7.5	7.5	7.75	7.25	7	7		
5/13/96	5.75	5.25	5.75	5.5	5.5*	5.5*	5.5*		
5/14/96	6.5	6.25	6.5	6.5	6.5	6.5	6.5*		
5/15/96	8.5	8	8.5	8					
5/16/96	8	8	8	8	7.5	8	7.75		
5/17/96	8.25	8	8	8	7.5	7.75	8		
5/18/96	8	8	7.75	7.75	8	7.75	8	7.5	
5/19/96	7.5	7.5	7.25	7.25	7	7.25	7.25	7.25	
5/20/96	7	6.75							
5/21/96	6.75	6.75	6.75	6.5	6.5	6.75	6.75	6.5	6.5
5/22/96	6.5	7	6.5	6.75	6.5	7	6.75	7	
5/23/96	7.25	7							
5/24/96	8.25	8	8						
5/25/96	7.5	7.5							
5/26/96	7.5	7.5	7						
5/27/96	7.25	7	7						
5/28/96	7.25	7.5	7						
5/29/96	7.25	7.25	7						
5/30/96	7.25	7	6.75						
5/31/96	6.25	6.75	6.5						
6/1/96	6.5	6.5	6.5						
6/2/96	6.25	6.25	6.25						
6/3/96	6.25	6.25	6.25						
6/4/96	5.75	6	5.75						
6/5/96	5.5	5.5*	5.5*						
6/6/96	4.5	4.5	4.5						
6/7/96	4.5	4.5	4.5						
6/8/96	4.25	4.5	4.25						

* No revolution data recorded. Average from previous sessions reported.

Rotary Screw Trap Revolutions - Lower Site, 1996

Date	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7	Session 8	Session 9	Session 10	Session 11
5/6/96	6	6.25	6								
5/7/96	6.75	7	7	8							
5/8/96	7.75	8	7.75	7.5	7.5						
5/9/96	7.5	7.75	7.25	7.5							
5/10/96	7.25	7.25	7.25	7.25	7.25						
5/11/96	7.5	7.5	7.5	7.75	7.5	8.25					
5/12/96	7.75	7.25	7.75	8	7.5	7.5					
5/13/96	7.75	7.5	6.5	6.5	7.25	7.25	7.25	7.25			
5/14/96	7.75	7.25	8	7.75	7.5	7.5	7.25	7.25			
5/15/96	6.25	6.25	6.25	7.5	7	7	7.25	6.75	7.25		
5/16/96	8	8	7.25	7.5	7.5	7	6.75	6.75	7		
5/17/96	7.25*	7.25	7.25*	6.25	7	7	7	7*			
5/18/96	7*	7	6.75	7	7	7	6.25	7	6.75		
5/19/96	6.75	6.5	6.5	6.5	6.75	6.25	6.5	6.5			
5/20/96	6.25	6.5	6.5								
5/21/96	6.25*	6.25*	6.5	6.25	6.75	6.25	6.25	6.25*	6.25	6.5	6.25
5/22/96	6.5	6.75	6.75								
5/23/96	7	7	7	6.75	7	7	7	7	7.25		
5/24/96	7.75	7.5	7.25								
5/25/96	7.25	7.25	7.25								
5/26/96	7.75	8	7.25								
5/27/96	7.5	7.25	7.75								
5/28/96	7	7.5	7.25	7.25	7.5	7.25	7.5	7.5	7.25	7.25	
5/29/96	7.25	7	7	7.5	7.5	7.5					
5/30/96	6	6	6	6	6	6.5	6.5	6.25	6.5		
5/31/96	6.75	6.5	6								
6/1/96	7	7	6.5								
6/2/96	6	5.75	6								
6/3/96	6.5	6	6								
6/4/96	6.5	6.5	6								
6/5/96	7	5.5	5.75								
6/6/96	4.5	4	4								
6/7/96	4.5	4.25	4.25								
6/8/96	4	4	4								
6/9/96	4.75	4.5	3.75	4	4	4.25	4.25	4			
6/10/96	5.25										

* No revolution data recorded. Average from previous sessions reported.